BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS

ASSOCIATION

(ENGLISH EDITION)

[656]

Competition by roads, waterways and airways.

(Continuation) [1].

Germany.

The General Management of the German State Railways has sent us the text of the law of the 4th December 1934, regulating passenger traffic by land in Germany, with an appendix forming a brief commentary on the main clauses of the law in question, relating to passenger road motor traffic.

* *

Law of the 4th December, 1934, on passenger traffic by land.

(From the Reichsgesetzblatt, Part I, No. 133, of the 10th December, 1934.)

In the national-socialist State, the organisation of transport is reserved to the State. The means of transport may be in the hands of the public authorities or of private individuals, but all must conform with the conditions drawn up uniformly for the whole State. Each means of transport must have assigned to it the duties it is most suited for in the traffic field as a whole and in the social econo-

my of the State. Thus a State transport code is needed, which will regulate, by means of various laws, the classes of traffic forming one single group. The German Government has issued, therefore, the following law, which regulates in a uniform fashion all forms of land transport for public passenger services, apart from the railways, and is promulgated to-day.

I. — General requirements.

§ 1.

(1) The law applies :

1. To commercial passenger transport by tramways and road vehicles whether horse-drawn or mechanical;

2. to passenger transport by the German Post Office.

(2) The law does not apply to railway passenger transport nor to the road motor vehicles of the German Post Office.

---

(1) See *Bulletin of the International Railway Congress Association*, June 1934 to March 1935.

§ 2.

A licence must be applied for :

1. by anyone wishing to operate tramways (tramway operator) ;

2. by anyone wishing to operate regular road motor omnibus services (regular road motor service operator) ;

3. by anyone desiring to operate occasional road motor services (occasional motor service operator).

§ 3.

(1) Tramways are railways used exclusively or mainly for the public conveyance of passengers within a district, as well as those which, while linking up neighbouring places, are much like local tramways by being mainly used for passenger traffic and by their construction and operating methods.

(2) The tramway class also includes aerial and underground railways having their own permanent way and providing public passenger services within a given district or between neighbouring places.

§ 4.

A transport undertaking is considered as a regular road motor service if, during any two consecutive months in the year, more than two journeys are made each week between given places and the service is open to the public. All other transport undertakings are not considered as regular road motor services.

§ 5.

(1) A licence is required :

1. in the case of a tramway, for the construction, equipment and operation of the said tramway ;

2. in the case of a regular road motor service, for the equipment and operation of the service ;

3. in the case of an occasional service, for the firm itself and for the number, nature and condition of the vehicles.

(2) Authority must also be obtained for :

1. all extensions or modifications of a radical nature to the undertaking and its equipment, as well as, in the case of an occasional service, any increase in the number of vehicles ;

2. the transfer to a third party of the rights and obligations attached to the licence ;

3. the transfer of the working to a third party.

§ 6.

The requirements of the present law cannot be evaded by fallacious applications of the text or possible mis-interpretations of the civil or commercial code.

§ 7.

When any doubt occurs as to whether a transport undertaking comes under the requirements of this law, the decision will rest with the higher administrative authority within whose jurisdiction the company operates or must operate.

§ 8.

The right to grant a licence belongs :

1. in the case of a tramway company and a road motor service, to the higher administrative authority in whose jurisdiction they operate.

2. in the case of an occasional service with road vehicles having not more than eight seats, including the driver's (hackney carriages), standing on hire on the public road or places, to the police autho-

rities of the district in which the undertaking has its headquarters;

3. in the case of all other occasional services, to the higher administrative authorities of the district in which the undertaking has its headquarters.

§ 9.

(1) The licence is only to be granted if the licensee is worthy of confidence, if the reliability and capacity of the company are guaranteed, and if the undertaking is not contrary to the interests of public traffic.

(2) The licence must be refused if there is no need for the service offered.

§ 10.

The licence is only granted to the operator temporarily and personally; the rights of third parties are unaffected.

§ 11.

(1) The undertaking is under the control of the authority issuing the licences as far as carrying out the legal requirements and the conditions of the licence is concerned.

(2) The Minister of Transport can delegate the technical control to other organisations.

§ 12.

The authority granting the licence can insist upon all legal decisions on the application of the police regulations being complied with.

§ 13.

The competent authorities can withdraw the licence if the operator infringes the obligations laid upon him by the present law or the conditions of his licence.

§ 14.

((1) The German Post Office Administration and the Reichsbahn require no authorisation to set up a regular road motor service, nor an occasional service worked with vehicles belonging to the regular motor service. The importance of such occasional services and the conditions upon which they are operated are determined by the Minister of Transport.

(2) The German Post Office Administration or the Reichsbahn are not entitled to operate an occasional service with vehicles used exclusively for such a service nor to operate a local service without the agreement of the local authority.

(3) Regular road motor services and occasional services operated by the Reichsbahn are controlled by the Minister of Transport.

II. — Special prescriptions.

1. *Tramways.*

§ 15.

(1) If the tramway is to make use of a public highway, the undertaking must obtain the consent of those who have to maintain this highway, and who are entitled to ask for a reasonable compensation for the use of the highway in question.

(2) If no agreement can be come to about the use of the road, the amount of the compensation, or on the continued use of the road should the installations have to undergo alterations, the authority granting the licences can take the place of the interested parties and fix the amount of the compensation.

(3) The requirements of clauses (1) and (2) also apply to tramway level crossings.

§ 16.

If required by the authority responsible for the maintenance of the public roads, on the expiration of the concession, the company must remove the tramway equipment and restore to good condition the part of the road used. The authority granting the licences can insist on a deposit for the due performance of these obligations.

§ 17.

(1) The transport rates and conditions, and the timetables, must be approved by the authorities granting the licence. They must be published before they come into force.

(2) The transport rates decided on must be applied uniformly. Reductions from which all do not benefit under equal conditions are forbidden and null.

(3) Other conditions can be laid down when granting the licence.

§ 18.

The licence is granted subject to its being completed and modified when the scheme is finally worked up.

§ 19.

(1) Constructional work can only begin after the licence has been granted, and the scheme ratified by the authority granting the licence.

(2) Ratification of the proposals includes the determination, in due legal form, of the site, layout and nature of the tramway in all its aspects.

§ 20.

(1) When the proposed scheme is approved, the company must provide all the equipment necessary, both in the interest of the public, and guarantee adjoining property against risks or deterioration.

(2) Maintenance of the equipment mentioned in clause (1) falls upon the operator so far as it lies outside the obligations relative to the maintenance of existing equipment serving the same object.

§ 21.

A period shall be fixed within which the tramway shall be completed and opened to traffic. The competent authority can declare the licence null and void if the work is not completed or the service started within the time laid down in the concession deed or any extension granted.

§ 22.

The opening of the service depends upon the agreement of the authority which granted the licence. Agreement will be refused if the essential conditions of the licence have not been fulfilled.

§ 23.

The operator must work the service regularly during the whole period of the concession and, if so required, must pay a deposit.

2. *Regular road services.*

§ 24.

The requirements of §§ 17, 21 and 23 also apply implicitly to regular road services.

§ 25.

The operator cannot evade or restrict by agreement the responsibility falling upon him towards the passengers carried by him. Agreements to the contrary are null and void.

§ 26.

The operator is obliged to insure against any claims which may be made against him, as regards his vehicles, by passengers carried or by other persons, and must produce his policy on demand to the authorities granting the licence.

§ 27.

(1) The requirements contained in § 17, clause (1), second part, and clause (2), are only applicable to regular services operated by the German Post Office or the Reichsbahn. The carriage rates, conditions of transport, and timetables of services operated by the Reichsbahn must be submitted for approval to the Minister of Transport.

(2) Four weeks before a regular service is set up, the German Post Office and the Reichsbahn must give notice, on the one hand to the higher administrative authorities of the district served by the projected service, and, on the other hand, to each other. If, within four weeks after notice has been given, opposition is made, either by the higher administrative authorities concerned, because the undertaking is against the public traffic interest, or by the German Post Office or the Reichsbahn, because their interests will be affected, the Minister of Transport will act as arbitrator. Any opposition holds up the introduction of the service.

3. *Occasional transport services.*

§ 28.

The requirements of §§ 25 and 26 also apply to occasional transport services.

§ 29.

The licence itself will state if it is only to be valid within the jurisdiction of the authority granting it, or if it is to be valid beyond the district concerned.

§ 30.

The licence can be refused if the licensee lives outside the jurisdiction of the authority granting the licence.

§ 31.

The licence is automatically cancelled if the licensee transfers the headquarters of his firm to a place within the jurisdiction of another licensing authority.

§ 32.

In the case of occasional services the vehicles of which are placed by the contractor at the disposal of the public on public highways and places, the following prescriptions shall be applied :

(1) The transport rates and the conditions, and, if need be, the timetables, shall be fixed by the authority granting the licence, and shall be published. The requirements contained in § 17, clauses (2) and (3), are also implicitly applicable.

(2) The competent authority can cancel the licence if the licensee has not carried out any occasional transports during a period of six months, or if he has used the licensed vehicles for other purposes.

§ 33.

The requirements of §§ 28 to 32 do not apply to occasional transport operated by the German Post Office or the Reichsbahn.

III. — Common penalties and temporary legal provisions.

§ 34.

The provisions of the present law do not in any way abrogate the requirements

of the law on transport by road motor vehicles of the 3rd May 1909 (Reichgesetzblatt, p. 437), or later amendments thereto, nor of the law on measures intended to keep railway undertakings open for public traffic, dated the 7th March 1934 (Reichsgesetzblatt II, p. 91).

§ 35.

(1) Appeal can be made against the decisions and regulations of the police authorities, to the higher administrative authorities who decide the matter without appeal.

(2) Appeal can be made against the decisions and regulations of the higher administrative authorities to the Minister of Transport. The decision of the Minister binds the tribunals and administrative authorities.

(3) The appeals mentioned in clauses (1) and (2) have a suspensory effect.

§ 36.

All the transport undertakings covered by the present law must comply with the requirements of the Reich in the matter of national defence.

§ 37.

The Minister of Transport has the right to call for information at any moment as to the nature and importance of the passenger traffic worked by the German Post Office, the Reichsbahn, and contractors who have obtained a licence under the terms of the present law.

§ 38.

Interurban traffic by motor vehicles starting from a point outside the country can be regulated by the Minister of Transport under the provisions of the present law. This also applies to interurban traffic within the country in motor vehicles coming in from abroad.

§ 39.

The Minister of Transport will issue the necessary judicial and administrative decrees to enforce the present law. He can, in particular publish prescriptions relating to :

1. the operation of transport services, and also, in the case of tramways, to their construction;

2. the taxes to be imposed by the authorities, to cover expenses concerning the concession and the control of transport undertakings;

3. to remedy the difficulties of transport firms.

§ 40.

(1) Whoever shall operate, intentionally or through neglect, without the necessary authorisation, any transport service using road vehicles, is liable to be fined or imprisoned for a period not exceeding three months.

(2) In addition, confiscation of the vehicles used may be ordered, even if these do not belong to the guilty party or an accomplice. If no definite person can be tried or condemned, confiscation can be ordered independently. Should the offence be repeated, confiscation must take place unless the vehicle has been used for the offence without the fault of the owner; or if the confiscation would be too excessive a punishment for the party concerned.

(3) If the judgment provided for in clauses (1) and (2) depends on knowing whether or not a transport service comes under the prescriptions of the

present law and sentence has not been passed according to § 7, the proceedings shall be adjourned until the question has been settled definitely. In cases in which the Minister of Transport has not come to any decision, the tribunal, if it wishes to appeal against the sentence of the authorities, mentioned in § 7, can ask the Minister to settle the case.

§ 41.

(1) A fine not exceeding 150 Reichsmark, or a term of imprisonment will be imposed upon whomsoever, apart from cases provided for in § 40, infringes, in the capacity of contractor or of employee of a transport firm, the provisions of the present law, the conditions given on the licence, or the prescriptions or decrees published for carrying out the present law.

(2) The provision of clause (1) is not applicable to the German Post Office nor to the Reichsbahn.

§ 42.

The German Post Office is authorised to continue to work, for a period of three years, the occasional road motorbus services with the vehicles it will own when the present law comes into force, and which are set aside for such services alone.

§ 43.

(1) The provisions of the present law shall be applicable to firms to which, in accordance with the legislation now in force, a licence has been granted for carrying passengers by land. If a permanent licence has been granted to a tramway, in accordance with earlier legislation, no modification will be made thereto.

(2) Rights acquired in a regular manner by all other persons remain unaffected.

§ 44.

The Minister of Transport will issue the necessary decrees to bring into force this new legislation.

§ 45.

The provisions of § 44 will come into force with the promulgation of the present law; the other requirements will come into force on the 1st April 1935. The same day will be rescinded the regulations relating to passenger transport, contained in the third decree of the President of the Reich, to safeguard the national economy and finances of the State and to combat political excesses, dated the 6th October 1931, Part five, Chapter V (Reichsgesetzblatt I, p. 558) as well as §§ 37, 40 and 76 of the Industrial Regulations, in so far as these concern public passenger transport by road motor or other vehicles within given districts.

* *

APPENDIX.

The new law of the 4th December 1934 on land passenger transport, which comes into force on the 1st April 1935, concerns, as is indicated in the first §, not only the transport of passengers by motor vehicles but also in vehicles drawn by animals as well as tramway traffic. In what follows, we will not deal with the requirements of the law on tramways and horse-drawn vehicles. In the struggle between rail and road, only the provisions of the law on motor passenger services are of interest.

The law makes a distinction between regular and occasional transport services. In the case of regular services, the existing legislation has been maintained to a great extent. Interurban services

must obtain a licence in every case. The licence is only granted if the service is really needed. It must be refused if the safety or capacity of the firm is not guaranteed, or if the undertaking is not in the public interest. In addition, the licence is also granted only temporarily, as in the past. Likewise, as in the past, a licence is only obligatory in the case of regular services which it is intended to work by means of motorbuses, i.e. with motor vehicles in which, according to the number of seats, more than 8 people, including the driver, can be carried. An innovation consists in the fact that, in future, it is stipulated in the law itself that a regular service is only counted as such when during a period of two consecutive months of the year, more than two journeys are made every month between given places. The legislation on the right of opposing the procedure for granting a licence is the same as previously.

Another point of particular importance for the Reichsbahn is that the new law now dispenses in principle the Reichsbahn also from asking for a licence. Up to the present, this privilege was only granted to the German Post Office. In the case of both Administrations, the law lays down the same notification procedure as is at present in use only in the Post Office Administration. In this notification procedure, apart from the right to oppose of the administrative authorities, there is only a mutual right of opposition between the two great transport services of the Reich. The Minister of Transport decides the case without appeal. The present provision according to which he must decide in agreement with the Postmaster General as far as the Post Office Administration is concerned, has become purposeless owing to the amalgamation of these two offices in a single portfolio, and consequently it has been omitted from the new law.

In the case of occasional transport, which up to the present was not covered by any legal requirements as regards concessions, the new law makes the application for a concession obligatory. However, this obligation does not cover single occasional journeys, but only professional firms undertaking special journeys. Services carrying out special journeys have still to obtain a licence if they are worked with small passenger vehicles. The licences for occasional transport are likewise only granted when there is a need for the service. Furthermore, the validity can be limited to given districts. As for undertakings working regular services, occasional transport services have to insure themselves adequately against claims for damages made by passengers carried by them or by a third party. Nor can they annul or limit, by means of an agreement, the responsibility which is legally theirs.

The German Post Office and Reichsbahn Administrations, in the future, can only work occasional services with vehicles used by them for their regular services. In the future, therefore, occasional transport will in principle be reserved for private firms.

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

INQUIRY INTO QUESTIONS OF IMMEDIATE INTEREST.

(Decision taken by the Permanent Commission at its Meeting held on July 29th, 1933.)

QUESTION II.

« The World Crisis and Railways

and the effects of the crisis on railway working; measures taken to lessen the effect of the crisis; competition or collaboration between railway and road transport; a forecast of the future; new ideas as to passenger transport, such as light quick trains between large towns and between large and small towns, running at regular intervals. »

REPORT

(Secondary Railways in Countries of Southern Europe, and their Colonies.)

By Messrs E. LAVALLE,

Ingénieur, Directeur de l'Office Technique Central de l'Inspectorat Général des Chemins de fer,
Tramways et Automobiles (Italy), Rome.

and E. MELLINI,

Ingénieur, Inspecteur supérieur de Vigilance à l'Inspectorat Général des Chemins de fer,
Tramways et Automobiles (Italy), Rome.

The railway industry, like all international activities linked up with the general interests and progress of the various countries, their development in all branches of human activity, and the wealth and welfare of humanity, is suffering from the present crisis. A world crisis, of a gravity never perhaps before experienced, because it is the result not only of a lack of equilibrum between the power to produce and the possibility to consume, but also and indeed chiefly of the tendency in most countries to close their frontiers to the products of other countries, and to encourage a series of new national industries, which are often anti-economic; the consequences of such action are definitely detrimental to international trade and the increase in the wealth of the civilised world.

Each day brings with it new restrictions in the trade between different countries, even countries where up to now the policy of free trade had been maintained. The policy of free trade is nearly everywhere being ousted by a policy of quotas, of prohibitions and barriers against the import of foreign goods. Consequently, international trade is growing weaker and weaker to the great prejudice of wealth in general, and with alarming effects upon the main line railways, as well as on the mercantile marine.

This shrinkage in international trade has in its turn a harmful effect upon the secondary railways serving agricultural districts where special products are collected, and whose industry and commerce depend upon their export trade. The result of this is financial and technical operating difficulties of a very

serious nature, which in many cases make it necessary to close down the railway.

Such a situation has arisen precisely at the period when heavy road lorry traffic (which has grown immensely with its diesel-engined motor trains) competes very seriously for all traffic, but in particular for local traffic.

Then too, the better class of tourist traffic, and an important part of the escorted tours, have been definitely lost to the road.

It is, therefore, not only a question of the railway losing its transport monopoly (a monopoly on which the railways lived perhaps too complacently for nearly a century), to which the different railways could adapt themselves usually by a more modern, flexible, and economical organisation of their resources, but also of the world traffic which, now only 30 or 40 % of its former value, has to be fought for in a merciless struggle between rail and road. It is difficult to improve the situation by governmental action, as it is not only hard to decide upon the action required, but it is even harder to enforce it.

In addition, such competition has developed under unfavourable conditions for the railway, because the road can offer, in many cases, definite advantages in commercial and tourist traffic such as : quick door to door transport; small consignments which require expensive packing when sent by rail, etc...; and in the case of tourist traffic, the possibility of organising excursions to visit more quickly and thoroughly the artistic, historical and scenic features of a country, with the assistance of authoritative guides, and in conjunction with the hotels of the district.

Mention must also be made of the fact that, as a rule, motor transport is subjected to much less stringent legislation than the railways, which have to meet many charges and obligations, such as the obligation to work a regular service and, in principle, to carry *all* traffic offered.

Tourist traffic, in certain countries, is of vital importance, and as an example, the fact may be mentioned that during the last three years the visitors to Italy arriving by rail were fewer than those by road; this falling-off in the railway traffic tends to become more marked. In this case, the passenger traffic concerned is a matter of millions.

This preamble may be closed by a reference to the other methods of transport in competition with the railway, such as inland waterways, airways, pipe lines for handling liquid products and gases, transmission lines for distributing electric power, etc... but luckily their adverse effects have not yet reached any high percentage, at least in most countries.

* * *

In spite of the heavy fall in world traffic during these years of crisis, in spite of the serious competition from motor transport, it must be affirmed and reaffirmed that the railways cannot be considered as an out-of-date method of transport doomed to disappear.

We must recognise that life has become harder in every field of human activity and that the railways are — at present — among the organisations most seriously affected.

Consequently resistance must be put up and the struggle maintained; in accordance with the words of Mussolini we must : « Durare nella fatica ». The railways still have a part of primary importance to play in the trade and life of Nations; they must make an effort and adapt themselves to the present conditions of trade depression and to road competition, assisted by means of national legislation and international agreements intended to paralyse if not destroy all uncontrolled or anti-economic competition in the future, and to

retain only such sound and useful competition as is useful in the trade and national interests in the different countries, until such time as world trade recovers the only way humanity can escape from the present difficult and uncomfortable conditions.

Is this recovery likely to begin in the near future ?

This question is very difficult to answer. There are, however, certain indications of better times coming, and these bring with them a more hopeful spirit.

As far as concerns production and trade in general and railway traffic in particular, the « Universal Trade Barometer » gives the following statistics for the principal countries of the world :

During the first eight months of 1934 (1st January to 31st August) the number of railway wagons loaded was 56 147 000.

Taking the same period each year, these figures show an increase of 8 % on 1933, during which the lowest level of the depression was reached with 52 209 000 wagons, and 7 % increase on 1932 with 52 313 000 wagons. The 1934 figures, however, still show a decrease of 33 % on 1928, which can be considered as a normal year with 83 328 000 wagons, and a decrease of 35 % in comparison with 1929 during which the traffic reached a maximum of 85 804 000 wagons.

The « Universal Trade Barometer » adds that, if the traffic during each of the eight months considered in 1934 is higher than for the corresponding month of the previous year, the increase has tended to fall off during the last few months.

As far as Italian production and trade are concerned, the statistics bring out the following facts : the general index for industrial production, taking the year 1928 as the basis, was 93.5 for the month of September 1934, as compared with 85.4 for the same month of 1933, whereas in the previous years (1929-1930-1931-1932), it was 111.5, 98, 86.5

and 77 respectively. The number of wagons loaded on the State Railways during the said month, increased from 390 829 in 1933 to 399 611 in 1934.

There are, therefore, some favourable signs in both the national and international spheres, of a traffic recovery in the near future, though the signs are still slight and, moreover, may be contradicted by actual events.

One thing is certain and that is that railway operation must be reorganised, simplified, modernised, and cheapened; most important of all, the goods rates must be lowered. This is the most interesting and most urgent part of the problem under consideration.

* * *

As far as future relations between rail and road are concerned, it seems to us that the following considerations must not be lost sight of.

The motor should be given, in the public transport field, its proper place in which it can be used to the general benefit of the country, even if the railway companies have in consequence to revise and alter their equipment and their operating methods so as to collaborate with the motor in the best way.

It should be remembered that, when the railways were started, there were no motors, and their services were completed by horse-drawn passenger and goods vehicles.

Now that such methods have been replaced by the fast vehicle of the century — the road motor vehicle — the former balance has been upset and must be re-established on a new basis. Neither the railway nor the road should be expected to bear alone the cost of solving the problem.

Guiding principles of a general nature must be laid down in an endeavour to limit excessive motor services and any possible opposition from the railway.

If such a policy were followed, will the motor eventually defeat the railway and take its place ?

At the moment, the reply would seem to be in the negative, even in the case of most of the secondary railways.

If the motor vehicle and the ordinary roads had reached their present development, and if steam or electric railway traction had not existed, the motor vehicle would necessarily have had to provide a general communication system. But had railways started at the same time or later than the motor, they would also have asserted themselves and have grown. The railway would have found its own field, if only for heavy traffic, with a preference for long-distance transport for which the motor is not suited.

At present, the railways are in a somewhat different position, it is true. They include *secondary lines* with light traffic carried in a small number of trains, the overall speed of which as a rule no longer meets public requirements. These lines are led to lighten their trains and make them more frequent and faster, at least in the case of passenger services, mainly by using motor traction.

They are in fact becoming motor services on rails.

Whatever is done, equilibrium will sooner or later be established on the basis of a general combined transport system, well organised and co-ordinated, in which the railway will have the preference in carrying goods in bulk over long distances, and the motor local traffic over shorter distances, besides acting as a feeder to the railways.

And if the Public Authorities see that each method of transport keeps to its own field of action within the limits imposed by its own nature, a satisfactory solution, the most economical as regards transport and the cheapest as regards trade, will be found.

This problem has been clearly presented in the introductory part of the report « Road and Rail » made to the International Chamber of Commerce by the Committee of Independent Experts (Bulletin No. 85, October 1933, of the International Chamber of Commerce, Paris).

* * *

The problem of adapting railway operation to the new requirements of trade and industry should, in our opinion, be examined from the following points of view :

1. *Introduction of suitable legislation for regulating in a national and useful manner the relations between road and rail;*

2. *Adoption by the railways of regulations to make their working more flexible, as regards both the public and the staff;*

3. *Use of the most modern and economical technical systems of railway operation in order to reduce expenditure, facilitate passenger movements and assist generally in recovering traffic;*

4. *Simplification of the rates and carriage conditions and general reduction of the goods rates.*

5. *Development of combined rail and road transport by the means offered by the present-day technique.*

* * *

Before starting to examine the problem under each of these headings, we consider it useful to reproduce the following table of the Operating Receipts and Expenditure from 1922 to 1933 for the whole of the small Italian railways operated by private companies.

Gauge.	Years.	Length of lines worked. Kilom.	Receipts per kilometre of line worked. Lire.	Expenditure per kilometre worked. Lire.	Working coefficient.
Standard	1922	1 836.722	69 046	70 015	1.01
	1924	1 963.639	82 592	72 705	0.88
	1927	2 128.014	95 272	82 466	0.87
	1928	2 159.910	92 124	77 309	0.84
	1929	2 168.025	92 412 .	77 998	0.84
	1930	2 192.974	81 902	71 711	0.88
	1931	2 270.266	64 796	61 010	0.94
	1932	2 579.539	51 985	53 709	1.03
	1933	2 745.409	45 461	47 507	1.04
Narrow	1922	2 397.611	25 941	40 714	1.57
	1924	2 517.382	28 828	34 389	1.19
	1927	2 724.031	34 643	39 567	1.14
	1928	2 744.933	33 590	39 456	1.17
	1929	2 813.581	32 922	39 282	1.19
	1930	2 992.753	29 877	36 420	1.22
	1931	3 070.167	24 320	32 830	1.35
	1932	3 147.289	20 045	29 578	1.48
	1933	3 178.313	18 248	27 796	1.52
Together	1922	4 234.333	46 657	54 116	1.19
	1924	4 481.021	52 329	51 138	0.98
	1927	4 852.045	61 234	58 382	0.95
	1928	4 904.843	59 366	56 125	0.95
	1929	4 981.606	58 812	56 131	0.95
	1930	5 185.727	51 876	51 344	0.99
	1931	5 340.433	41 528	44 810	1.08
	1932	5 726.827	34 432	40 448	1.17
	1933	5 924.722	30 855	36 925	1.20

This table shows that, in spite of all the efforts to reduce expenditure, the Italian privately-owned secondary railways are in the same position as similar railways in other countries covered by the reports.

* *

I. — Introduction of suitable legislation for regulating in a rational and useful manner the relations between road and rail.

This question concerns the main line railways just as much as the small systems; consequently without dealing with the whole legislation given in the reports on main-line railways, we will limit ourselves to mentioning a decree of the Italian Government on the steps taken to improve the position of railways working under concession, i. e. the secondary railways, — which on the 31st December, 1933, had a length of 5 955 km. (3 700 miles) or about one third of the State Railways (16 886 km. = 10 993 miles).

This decree — dated the 14th October, 1932 — provides for the possibility of compulsory regional regrouping of railways and motor services, and regu-

lates the withdrawal of concessions already in force.

It also makes provision for replacing the passenger or goods services, over the whole or part of a railway, by public motor services or by trolley buses, or the adoption of new methods of traction, or the simple discontinuance of all or part of the services.

After sufficient experience — two years at the most — the conditions of the concession or subsidy are revised.

In the case of lines which, after such steps have been taken, or even before, it is judged advisable to do away with, the concession may be withdrawn.

The dismissed personnel has a right to preference for admission on the staff of the new regrouped lines.

The managements are empowered to grant temporary reductions in the rates, without any preliminary authorisation from the Ministry of Communications; any definite modification must, however, be approved by the said Ministry.

Up to the present, few railways have made use of the facilities summed up above; several have investigated the possibility of a conversion, but on the 31st December, 1933, only eight lines had replaced their passenger services by road buses, as is shown in the following table :

Road motor services operated in 1933 instead of railway services on secondary lines.

LINES.	Services discontinued.	Date road motor service started.	Road motor services. Kilom. (Miles).	Passengers carried.	Operating receipts. (Lire).	Operating costs. (Lire).
Massa Marit - Follonica-Porto	Passenger.	1-2-1933	52.585 (32.7)	22 842	108 919	94 419
Aquila - Capitignano . .	»	15-10-1933	16.325 (10.1)	8 988	35 243	59 271
Bosa-Macomer-Nuoro . .	Passenger service, partly.	29-10-1933	29.311 (18.2)	7 687	41 955	73 704
Rovereto-Riva	»	18-11-1933	—	—	—	—
Cividale-Caporetto . . .	Whole traffic.	1-8-1932	63.455 (39.5)	26 755	121 199	108 508
Fano-Fermignano . . .	»	1-1-1933	99.720 (62.0)	30 694	167 441	131 050
Castelraimondo-Camerino.	»	3-12-1930	67.452 (41.9)	38 075	122 535	168 630
Mandela-Subiaco . . .	»	1-12-1933	—	—	—	—

II. — Adoption by the railways of regulations likely to make their working more flexible as regards the public, the staff, etc.

As the public have now come to appreciate the great flexibility of road transport, the railways must adopt systems of rates, waybills, delivery times, packing, formalities, delivery, responsibility, claims, and compensation procedure of a much simpler nature than those used up to the present.

This question affects both main line and small railways, and consequently should not be dealt with here, so as not to repeat the arguments already brought forward in the reports on the main line

railways, or, what would be worse, in a conflicting way.

* * *

A new system of rates introduced by the Rome-Fiuggi-Frosinone Railway for goods carried in complete wagon loads should be noted.

The ordinary goods rates are a complete innovation in comparison with the previous tariffs. It has several advantages, i. e. : reduction in carriage charges, elimination of all difficulties for the public, and uniform rates for all kinds of goods.

The rate is shown on the part of the waybill detached and given to the consignor who consequently can easily check the correctness of the amount paid, besides knowing what future consignments will cost.

This rate is calculated in the following way :

1. The number of tons of goods must be multiplied by 0.12 lira, odd tons under ten being counted as ten tons. Every fraction of 5 centisimi in the total is counted as 5 centisimi.

2. A charge must be added for every wagon used, varying according to the type of wagon. These charges are given on the said waybill coupon.

3. The tax of 0.025 lira must also be added for each 1 000 lire or part of 1 000 lire of value declared. Each fraction of 5 centisimi in the total is counted as 5 centisimi.

4. The result of the above operations is multiplied by the number of kilometres the goods are to travel. Each fraction of 10 centisimi in the new total is counted as 10 centisimi. In this way the cost of the consignment is arrived at.

A system like this is naturally only feasible on a railway where the number of classes of goods is limited and the goods traffic is small, but it shows the value of reducing the number of rates, usually very large on the railways, to the annoyance of the users, whereas

motor transport practice is the very opposite.

III. — Use of the most modern and economical technical systems of railway operation in order to reduce expenditure, facilitate passenger movements and assist generally in recovering traffic.

It is very necessary, at the present time, that the most modern and economical technical systems of operation, especially in the case of railways, and above all for secondary lines with small traffic, should be carefully studied, both to improve the financial situation and to meet the ever increasing requirements of the passengers.

The replies received from the various Administrations to whom the questionnaire was sent, were few in number, and in most cases very incomplete. We will not reproduce the latter replies here as they are of no real importance.

We will limit ourselves to the information supplied by three secondary railways : the *Société Générale des Chemins de fer Economiques*, Paris, the *Piedmontese Tramway Company*, of Saluzzo, and the *Compagnie française des Chemins de fer de l'Indochine et du Yunnan.*

* * *

The *Société Générale des Chemins de fer Economiques* (Paris), operates in France self-contained autonomous railway systems in more than twenty Départements, none of which is connected with any other; this leads to a variety of operating methods in marked contrast with the practice of main-line railways. The length of the lines worked is as follows :

Steam lines . . 3 589 km. (2 230 miles)
Electric lines . 23 km. (14.3 miles)

Many of the systems operate mixed trains partly by rail motor coaches or road buses. The various lines are not very difficult, as the gradients do not as a rule exceed 1 in 33.

During 1933, the distances run were :

Steam traction	6 358 894 km.	(39 513 020 train-miles)
Electric traction	36 411 km.	(22 625 train-miles).
Petrol rail motor coaches . .	996 947 km.	(619 485 train-miles)
Diesel omnibuses	738 315 km.	(458 775 train-miles).

The average receipt was 7.15 fr. per train-kilometre (11.51 fr. per train-mile) the average cost 11 683 fr. The decrease in comparison with the year 1932 is 15.7 % on the receipts per kilometre, and 7.4 % on the corresponding expenditure. The financial position is therefore quite obviously very serious.

The principal cause of the drop in passenger receipts is the reduction of the ressources of the railway's customers on account of the present economic depression. However, road competition too is far from negligible; there is continuous competition from organised Companies as well as from occasional road motor hauliers.

The decrease in the receipts and number of passengers has reached the following percentage :

Decrease.	In 1933	
	in comparison with 1929.	in comparison with 1932.
In numbers . .	30.6 %	10.1 %
In receipts . .	31.1 %	13.7 %

The methods adopted to overcome the effects of the crisis and of competition may be summed up as follows :

a) Whenever possible, certain of the isolated systems have been attached to a larger system or have been grouped together for administration purposes;

b) The timetables have been revised and improved as far as possible;

c) Certain stations of minor importance have been made into halts and opened only at train time for reasons of economy;

d) The repair shops have been centralised whenever possible.

The labour employed has been reduced by the purchase of machine-tools as well as the drawing up of rational maintenance programmes strictly limited to the absolute needs of the service.

The staff in addition are required to fill in each day cards showing the work done and this has made it possible to control the way each man is employed;

e) The whole of the permanent way maintenance has been brought under a programme. The replacement of sleepers, a record of the age of which is kept by each railway, is fixed at about 5 % of the total number of sleepers used in the track.

As early as 1923, the Company tried out, and has since introduced, the practice of making gangs responsible for long sections, the track being maintained on the general overhaul method.

Each gang maintains some 30 km. (18.6 miles); it consists of 8 to 10 men who are taken to their place of work by a motor truck which at the same time hauls a trailer loaded with the tools and material required.

The staff is concentrated as far as possible at the centre of the section where the motor truck is also kept.

This organisation is satisfactory technically, the track being generally repaired, methodically, in a cycle of about 4 years.

The economic results are shown by an annual saving of more than 1 750 000 francs for the 87 long-section gangs that have been formed, and who maintain a total length of 2 706 km. (1 681 miles), i. e. 75 % of the length of the system;

f) The passenger service has been separated from the goods service by the introduction of light trains and by the use of petrol or diesel rail motor coaches.

The saving obtained by these measures is about 15 % on the traction costs of an ordinary train when replaced by a light train, and about 50 % when the replacement is by a rail motor coach. The station costs, rolling stock repairs, permanent way maintenance, and miscellaneous expenditure remain more or less constant.

The savings effected by the other measures indicated above have been as follows : the total expenditure was reduced by 0.93 % in 1931 in comparison with 1930; by 5.93 % in 1932 in comparison with 1931, and by about 6 % in 1933 in comparison with 1932;

g) The introduction of fast rail motor coaches has made it possible to stop the increasing reductions in receipts on certain lines with a large passenger traffic.

The greater comfort and speed have made it possible to fight road competition more or less effectively.

Some of the systems have also introduced road motor services to replace or extend the regular trains. This method effects substantial operating economies, and although, in a general way, the receipts do not cover the expenditure for carrying out the service, competition is met, and the regular passengers are retained by the railway.

* * *

The Piedmontese Tramway Company (Saluzzo) operates, in northern Italy, a light railway system of which

67 km. (41.6 miles) is steam traction;
120 km. (75 miles) electric traction with accumulators;
38 km. (23.6 miles) petrol road buses.

The gradients are somewhat heavy, as there are long gradients of more than 1 in 33 on the lines worked with steam and electric traction, and where petrol omnibuses are used, the gradients also exceed 1 in 16.

During the year 1933 the number of kilometres (of miles) worked was as follows :

	Train-km.	Train-miles.
Steam traction .	419 185	260 474
Electric-accumulator traction .	405 622	252 046
Petrol omnibuses.	53 074	32 979

The average receipts were 5.20 lire per train-kilometre (8.37 lire per train-mile) and the average expenditure 5.32 lire (8.56 lire per train-mile). In the case of the omnibuses, the corresponding figures were 3 127 and 2 532 lire.

The decline in comparison with the year 1932 is 5.92 % in receipts, and 5.94 % in costs, by railway, and 2 791 % and 2 042 % by road.

The main cause of the fall in passenger receipts is the decline in traffic owning to the economic crisis. The passenger traffic statistics are as follows :

Passenger transport.

Year.	Receipts.	Decrease.	Number of passengers.	Decrease.
1933 . . . . 1932	2 444 764 2 481 254	1.470 %	1 055 613 1 086 787	2.868 %
1933 . . . . 1929	2 444 764 2 820 580	13.324 %	1 055 613 1 229 513	14.143 %

The steps taken to counteract the effects of the crisis have been summed up by the Company as follows :

More convenient timetables, shorter stops at stations, better connections at terminal stations with the trains of other railways, and higher train speeds, have somewhat helped in preventing the public going over to other methods of transport. But the step which has given the best results in retaining passenger traffic, in spite of the crisis, has been the introduction of electric-accumulator rail motor coaches, which were put into service, in 1930 on the Turin-Saluzzo line, and in 1933 on the Saluzzo-Coni-Dronero line. The economic results of this change in the method of traction can be summed up as follows by the figures given below, relating to a train of 60 tons.

Average expenditure.

Steam traction :		Per train-km.	Per train-mile.
a) coal . . . . Lire		1.097	(*1.765*)
b) oil and lubricants		0.100	(*0.161*)
c) locomotive feed water		0.055	(*0.088*)
d) driver, fireman and guard		1.152	(*1.853*)
e) labour for maintenance of locomotive		0.078	(*0.126*)
f) material for above maintenance		0.152	(*0.245*)
Total . . Lire		2.634	(*4.238*)

Accumulator traction :			
a) Electric power . . . . Lire		0.173	(*0.278*)
b) Upkeep of the battery		0.680	(*1.094*)
c) Labour for charging battery and maintenance of equipment in connection therewith		0.122	(*0.196*)
d) Oil and lubricants		0.036	(*0.058*)
e) Driver and second man		0.415	(*0.668*)
f) Labour for maintenance of rail motor coach .		0.053	(*0.085*)
g) Material for above maintenance		0.110	(*0.177*)
Total . . Lire		1.589	(*2.556*)

* * *

The *Compagnie Française des Chemins de fer de l'Indochine et du Yunnan* has given us the following information on the passenger traffic of the railway :

—	Passenger receipts all classes.	Luggage receipts (nearly all 4th class).	Total passenger and luggage for all classes.	Comparison.
	←———— Francs.————→			1933-1929
1929 . . .	17 365 000	3 175 000	20 540 000	——————— = — 48 %
				1929
1932 . . .	11 209 000	2 114 000	13 323 000	
				1933-1932
1933 . . .	9 044 000	1 713 000	10 757 000	——————— = — 19 %
				1932

—	Number of 1st, 2nd and 3rd-class passengers.	Number of 4th-class passengers.	Total number of passengers.	Comparison.
1929 . . .	107 869	3 482 977	3 590 846	$\dfrac{1933\text{-}1929}{1929} = -38.8\%$
1932 . . .	64 656	2 646 734	2 172 390	
1933 . . .	39 047	2 157 739	2 196 786	$\dfrac{1933\text{-}1932}{1932} = -18.9\%$

The reduction in the receipts and number of passengers is due to the decline in the resources of those living near the railway in the case of 4th-class passengers, or to motor competition, and also to that of horse-drawn or hand carts, especially in the Tonquin delta. The freedom enjoyed by motor competition considerably increases the damage it causes to the railway. The two routes where there is the most competition are: Hanoi to Hai-Fong and Hanoi to Phu Tho.

In the case of 4th-class passengers, competition is mainly due to canvassing and offering lower prices; the canvassing takes place as near the station as possible, and the price is usually fixed after argument. The most diverse combinations of free transport for either children or passengers' luggage, or for passengers with luggage, are offered in this pursuit for customers.

Competition in the case of the 1st, 2nd and 3rd-class passengers depends on the speed and the frequency of motor transport, and the adoption of an intermediate rate between the 2nd and 3rd-class railway fares.

The Company declares that no effective steps have been taken up to the present, either to see that the highway code is obeyed by motor firms, nor to impose special taxes on firms in direct competition with the railway.

The steps taken by the Company to meet the effects of the crisis have been as follows :

a) Conversion, on certain sections, of a mixed passenger train (also picking up goods) into combined goods-passenger trains at lower speeds, to cover the slow goods service without delaying the working;

b) Introduction of halts for passenger traffic and accompanied luggage (4th class);

c) Native guards and ticket collectors replaced Europeans;

d) Transfer of the accountancy work of the Central Shops at Gia-Lam to the Chief Mechanical Engineer's department;

e) Standardisation of locomotive, carriage, and wagon parts;

f) Reduction of the permanent way maintenance costs by a more rational distribution of labour. The number of districts has been reduced from 24 to 21 by increasing the length of the more easily maintained sections from 30 to 50 km. (18.6 to 31 miles).

The European staff, which numbered 69 in 1931, has been reduced to 53 at the 31st December, 1933.

The native staff during the same period decreased from 1 800 to 1 499.

The Company is investigating the possibility of using rail motor cars for cer-

tain traffic, introducing light units, speeding up the trains, increasing their frequency, improving the standard of comfort offered, getting out timings at regular intervals or at more convenient times.

* * *

It is obviously impossible to draw any general conclusions from the information supplied by the above three Companies. It can, however, be affirmed that the most usual tendency is to fight the effects of the crisis and motor competition by giving up steam traction as far as possible, and using various types of rail motor coaches.

Similar conclusions were arrived at as far back as the Madrid Congress in 1930, in one of the reports on secondary railways[1]. In the case of passenger traffic, particular emphasis was laid, in fact, on increased train speed and frequency, the running of light trains made up of, or hauled by, rail motor coaches, etc., and direct operation or control of competing public transport undertakings.

From 1930 to the present day, the financial position of the railways (and in particular of the secondary railways) has become more and more serious through the extension of the crisis and the introduction of heavy road motor traction by means of diesel engines.

It must, however, be added that the problem of adopting the very economical diesel engine to railway traction has already been solved, in practice, in the case of engines of from 250 to 300 H.P., as regards ease of starting, regular running, transmission, weight and loading gauge.

Moreover, diesel units of higher horse power are already on the market, such as the new high-speed vehicles fitted with two 400-H.P. diesel engines and electric transmission, for the Italian State Railways, which are being built at the Fiat Factory, at Turin.

Without overlooking other ways of modernising and simplifying railway operation (centralised management; declassification of stations; transfer of rolling stock repair shops to private firms; contracting out the general permanent way maintenance work, etc.), the investigation into the possibility of improving railway operation should be in the direction of the use of rail motor coaches with diesel engines, either to reduce the cost per train-kilometre, or to facilitate the introduction of light, fast, and cheap trains, or to provide a sufficiently intensive train service to meet the ever growing needs of the public, and to meet motor competition.

Lighter vehicles.

The problem of making vehicles lighter for economical transport, in all classes of traction, has a certain interest for secondary railways and tramways which, on account of the decline in traffic, due to the present depression and motor competition, must in the future discontinue the running of heavy, slow and costly trains.

A detailed investigation into this subject has been made in Italy on the initiative of the « Comitato per l'Ingegneria del C. N. R. » which examined the question under the following aspects :

a) Higher capacity vehicles (vehicles with several decks, bogie carriages, bogie vehicles with long bodies, articulated carriages, etc.);

b) Improved metal parts for lightening vehicles (high-tensile steels, light alloys, special rolled sections with favourable inertia moments, etc.). The use of special rolled sections can by itself reduce the weight of a rail motor coach by 40 %;

c) Technical methods (welding, wel-

[1] See Mr. MELLINI's report, *Bulletin of the Railway Congress*, November 1929 issue, p. 2657.

ded frames, tubular body, streamlined shapes, etc.);

d) Special constructional features to ensure silent and easy running;

e) Stability and lightness of the vehicle relatively to the maximum running speed;

f) Savings resulting from lightening the vehicles.

This last matter is naturally the more important, and some of the practical conclusions from the Commissions' report may be stressed :

1. When the weight of a vehicle is reduced by using high-tensile steels or light alloys, the cost of the said vehicle is as a rule higher than when ordinary materials are used.

2. The operating savings resulting from the use of lighter vehicles, are calculated by multiplying the tonne-kilometres saved annually by the transport cost (traction costs) of the gross tonne-kilometre.

3. The saving resulting from light trains and vehicles is greater in the case of trains which have to accelerate quickly after each stop, and run at high speeds, but for short distances.

4. The lightening of vehicles and trains gives particularly good results in the case of railways with heavy gradients.

5. The light vehicle causes less wear to the permanent way, and consequently saves on maintenance.

Finally, the light train and vehicle prove more and more economical for railways in cases where the transport crisis and road competition have reduced the traffic to such an extent that the old heavy stock is worked at a loss.

IV. — Simplification of the rates and transport conditions and general reduction in the total carriage charges for goods.

The goods traffic on the lines of the *Piedmontese Tramway Company*, for the years 1929, 1932 and 1933, is shown by the following figures :

Year.	Receipts.	Decline.	Tonnes.	Decline.
	Lire.			
1933	1 810 406	— 19 %	112 834	— 12.5 %
1932	2 235 752		128 957	
1933	1 810 406	— 45.1 %.	112 834	— 37.2 %
1929	3 301 505		179 762	

The decline in the receipts is due for the most part to the depression which affects consignors, and also to the reduced rates granted to fight motor competition.

The same thing was reported by the *Société Générale des Chemins de fer Economiques* (Paris), which had, in 1933 in comparison with 1929, a reduction of 28.3 % in tonnage, and 31.2 % in receipts; in comparison with 1932 a reduction of 23.8 % and 23.4 % respectively.

The reduced rates, introduced on some railways in 1932, did not give good results and the decline is chiefly due to the trade depression.

As far as retaining the traffic and recovering lost traffic is concerned, some results were obtained by detail rating measures, by setting up new loading and unloading points; in addition, by providing private sidings at cheap rates, the railway possibly sharing the cost of construction, an appreciable part of the lost traffic was recovered.

Door to door transport facilities, by collection and cartage services worked by the railway itself, in certain places in a given district, are being introduced or under consideration.

Demurrage charges have been reduced for a long time, and the Company has been very liberal when considering the demands put before it.

Containers or tranship wagons have only been used to a restricted extent, and tests being made of these devices have not yet given the results expected.

As a rule the goods are carried short distances only, and in a very short time so that any further acceleration is impracticable.

Interesting results have been obtained in preventing the loss of traffic by means of agreements with road hauliers, through which road transport has been replaced by mixed railway transport combined with express goods grouped traffic on the main-line railways.

A service whereby goods are collected, carried to the departure station, carried over the railway, and the consignments grouped for conveyance over the main-line railway with delivery at destination by a motor transport firm under contract, is under consideration.

* *

The *Compagnie Française des Chemins de fer de l'Indochine et du Yunnan* reports a decline of 9.3 % in the tonnage, in 1932 as compared with 1929, due in part to lack of trade and partly to road competition, the latter much aggravated by the freedom enjoyed by motor competition with its very cut rates.

From 1932 to 1933, there was a considerable increase in tonnage and receipts as shewn in the following tables :

Receipts.

Year.	Parcels, dogs and horses. (Expr. goods).	Goods, carriages, cattle. (Slow goods).	Total.	Comparison.
	Francs.	Francs.		$\dfrac{1933\text{-}1929}{1929} = -\ 9.3\ \%$
1929 . . .	1 868 000	31 286 000	33 154 000	
1932 . . .	3 067 000	24 683 000	27 750 000	$\dfrac{1933\text{-}1932}{1932} = +\ 8.4\ \%$
1933 . . .	2 564 000	27 516 000	30 080 000	

Tonnage carried.

Year.	Parcels. Registered parcels. Postal packages. (Fast goods).	General goods. (Slow goods).	Total.	Comparison.
	Metric tons.	Metric tons.	Metric tons.	$\dfrac{1933\text{-}1929}{1929} = -\ 17.2\ \%$
1929 . . .	6 078	310 047	316 125	
1932 . . .	6 603	219 108	225 711	$\dfrac{1933\text{-}1932}{1932} = +\ 15.9\ \%$
1933 . . .	7 163	254 434	261 597	

The increase in the express goods receipts between 1929 and 1932 is due to the transport of silver ingots from Hai-Fong to Yunnanfou and to a great increase in the number of postal packages carried.

The increase in the goods receipts, in 1933 compared with 1932, is due to events in Shanghai, at the beginning of 1932, which temporarily paralysed the traffic into China.

Transit traffic, which was maintained to a remarkable extent, prevented any falling off in receipts for slow goods.

The goods most affected in the Hai-Fong-Yunnan transit traffic are mainly petrol and goods from places other than China.

The Yunnan-Hai-Fong transit traffic which is affected is the skin trade, the world markets of which have collapsed, whereas the export of tin, on the contrary, is increasing appreciably.

In the Tonquin, the traffic most affected is the import traffic from France (manufactured goods and consumable products) and, as far as internal traffic is concerned, the transport of rice and paddy, native alcohol and materials of all kinds.

In the Yunnan, in internal service, the traffics most affected are timber and vegetable and mineral fuels, with the exception of lignite.

The Company is experiencing difficulty in retaining the goods traffic owing to road and waterway competition and the falling off of the resources of its customers. Competition from horse-drawn vehicles makes itself felt over distances up to 40 km. (25 miles).

As far as the rolling stock is concerned, to the information given in the previous chapters, the following should be added.

In the case of locomotives, as the line may be interrupted during the rainy season, a locomotive repair shop has had to be maintained at ‘Tché-Ts’ousn,

otherwise medium and heavy locomotive repairs take place at the main shops at Gia-Lam.

Three types of locomotive are used and entirely meet the requirements on the different sections of the line; as far as possible, detail parts have been standardised.

The different parts of the carriages have likewise been standardised as much as possible : all the frames are alike; all 10-ton and 20-ton wagon frames are similar, and all axles and axle boxes of both wagons and carriages are interchangeable.

At the Gia-Lam shops the repair costs are apportioned under certain headings, so that the variations in expenditure of all the most important items can be followed up. The accountancy, in the case of new work, is separate.

All employees receive premiums, which vary in the case of the shed staff according to the savings made in oil and coal. The premiums are fixed in the case of the men employed in the Gia-Lam shops; they are reduced in the case of poor output or bad workmanship.

Trials of mechanised methods for packing the track and for the periodical overhaul of metal bridges — scaling, scraping and spray painting (pneumatic equipment, Ingersoll Rand engine) — have been tried.

These methods had to be abandoned, as the costs were higher than for manual work, on account of the cheapness of local labour.

The track is laid on metal sleepers, for the most part (nine-tenths of the system) on Micheville type sleepers with curvilinear section with the ends forming a spur in the ballast. This type of sleeper and its fastenings having given satisfaction as far as stability of the track is concerned, no improvements have been considered necessary.

However, provision has been made to substitute standard 30-kgr. (60.5 lb. per

yard) rails, 12 m. (39 ft. 4 1/2 in.) long, for the 25-kgr. (50.4 lb. per yard) rails, 9.58 m. (31 ft. 5 in.) long.

* *

V. — Development of combined road and rail transport by the technical methods now available.

The change due to the loss of the monopoly the railways had in practice up to recent years in land transport on the one hand, and the interdependence of the different means of communication on the other, require, in the public interest, a national co-ordination of railway and road transport and the development of joint transport, which must be efficient, fast and cheap, and meet the needs of industry, trade and the general public.

The technical study of this important aspect of land transport has only been taken in hand recently, and although more or less important trials are being carried out in most countries, it may be said that nothing practical has been done so far.

The *Société Générale des Chemins de fer Economiques* (Paris) has made the following remarks on this important question :

a) Co-operation with road transport firms has been sought after in every case where it could give satisfactory results, and has been achieved, according to the particular circumstances of each case, in various different forms.

In certain cases we have been able to absorb our competitor, by using him as a contractor for motor services instead of, or in addition to, the railway services. In other cases, total absorption was not possible, and we had to be content to limit the competition to some extent by leaving the road haulier a certain field of action, restricted, however, by the special timings or rates imposed.

Another method used was to collect from the competitor, for the benefit of our own service being competed with, a money payment based on the traffic taken away from the railway.

b) Containers or transhipment wagons have only been used to a restricted extent on our railways, and the trials being carried out with such devices have not given as yet all the results hoped for.

c) Interesting results have been obtained in preventing the loss of traffic by making agreements with road firms, by which exclusive road transport was replaced by combined road and rail transport, the method including express grouped transport on the main-line railway.

We are also investigating a service under which the goods would be collected, conveyed over our railway, sent as a grouped consignment over the main-line railway and delivered to destination, by means of an agreement with a motor transport firm.

The different measures detailed above have shewn very appreciable financial returns, and have made it possible to recover and develop certain traffics.

* *

The *Piedmontese Tramway Company* (Saluzzo)) have not given us any particular information on the subject.

They point out that the secondary railways and tramways are subject to many legal requirements as regards safety of running, publication of rates, etc., and have to bear heavy charges, part of which are due to the cost of maintaining the permanent way, replacing sleepers and rails, etc., while buses and lorries have complete liberty as regards rates and timetables, and can select the most remunerative traffic.

Road transport can also avoid the charges and obligations to which the railways and tramways are subjected

as regards wages and working hours, and other staff regulations.

The Company stresses the need of a fairer redivision of charges falling upon the different categories of passenger and goods transport.

* *

The *Compagnie Française des Chemins de fer de l'Indochine et du Yunnan* stresses the need for replacing competition in which the cutting of rates means an increasing charge upon the community (tax-payers) by regulated collaboration which would lead to certain kinds of traffic being given up.

The Railway, having no longer a monopoly, should be allowed to make private agreements, in the absence of which they will always run the risk of seeing their efforts in tariff matters only resulting in a lowering of the rates of their competitors, without any profit to the railway itself.

On the other hand, it is becoming more and more necessary to regulate motor services running parallel to the railway. This has been proposed by the Public Works Department, but has not yet been done.

Regulations applicable to firms operating services in direct competition with the railway, which have been considered in Indo-China, included payments in proportion to the capacity in passenger-kilometres or tonne-kilometres of the firms as compensation. This way of limiting competition is the one best suited to local conditions (Tonquin).

As for the obligations to be imposed upon road transport, it should at least be made to respect the road regulations and those concerning the safety of passengers. It is a regrettable fact that in a great many cases the existing regulations can be openly infringed.

The *Compagnie Française des Chemins de fer de l'Indochine et du Yunnan*

finally expresses the opinion that it would be a good thing if the railway and the road entered into agreements with regard to preferential rates or combined fixed rates for certain services where the road constitutes an extension to the railway; financial aid from the public authorities could help by guaranteeing loans for the purpose of improving the track and stock.

* *

The above three Companies (nor the other railway companies who replied to the questionnaire) have not supplied any particularly important information on the question of combined road and railway transport, considered from the technical point of view. It is true that, for the time being, the Companies operating secondary railways are leaving to the main-line railways and public authorities, the study of this problem as also the trials of new equipment and methods (containers; road-rail vehicles; fixed plant in the railway stations having joint railway and road transport services; agreements between railways and road firms for collecting and delivering parcels in door to door services, grouped goods, etc.) and prefer to meet the unfavourable situation revealed in their budgets by asking for subsidies from the Government, Provinces or towns, by making savings in staff and in the organisation of the operating department and by altering their traction and operating methods as discussed in the preceding chapters.

On the other hand, it is quite clear that the great majority of secondary railways have not sufficiently large financial resources at their disposal to be able to spend money on trials, the results of which may still be doubtful; furthermore, there lacks, between the said companies and the motor transport firms, that feeling of cordial understanding needed for investigating

and drawing up direct agreements to solve the problem of road and rail competition in the most rational and favourable way for the traffic requirements and the needs of the public.

This important question must, therefore, be regulated by laws of a sufficiently general nature to be applicable to the country as a whole, and which will deal not only with the concession-holders of officially recognised public transport, but also with private firms and owners who carry out transport on behalf of a third party.

As far as the question of joint transport is concerned, it would appear of value to report the solution now being achieved in the Italian Colony of Erythrea for mixed road and railway transport between the interior of the country and the Red Sea. The railway of the Colony links up the port of Massua with the capital Asmara (altitude 7874 ft.) and has an extension via Cheren (altitude 4920 ft.) and via Agordat as far as Biscia in the Sudan plain. From Biscia to the centre of the great cotton fields (Tessenei) a road for motor lorry traffic is under construction, which will be open to public traffic. In the connecting railway station of Biscia, provision has been made for ample garage accomodation with water, petrol and gas-oil tanks, a small repair shop with facilities for washing and greasing motor vehicles, etc. Apart from the services these garages offer the public, lorries belonging to the Management of the Colonial Railways will be stationed at them, and goods collected at the Biscia station will be sent by railway for the distance between Biscia, Asmara and the Red Sea. Special rates and facilities will be adopted to ensure that such joint transport will receive markedly preferential treatment, in comparison with free motor transport between the plain of Tessenei, Asmara and the Red Sea.

By this apparently rational solution, it is hoped to absorb practically all the traffic of the Colony, which, as regards transport between the Tessenei plain and the sea, with the gradual decline of the caravan trade, might have been taken over by private hauliers to the great prejudice of the railway's budget.

* *

Conclusions.

The position of the secondary railways, as it appears from the information supplied by the three Companies quoted above (to whom we offer our most cordial thanks) and from information collected directly by the Reporters, is very serious at the present time, both on account of the severity of the world economic crisis, and the ever increasing competition from road transport.

The position, however, is not so completely hopeless, that abandonment of most of these transport undertakings in the near future is to be considered as unavoidable. The study of the steps likely to meet the present situation is rendered still more difficult by the instability of the traffic in the different countries, and by the great uncertitude as to how long the present crisis will last, and as to when the falling off of business will end in most of the said countries.

In this report, we have affirmed our confidence that business and trade in general will recover; we hope at least for an improvement in the traffic the serious decline in which, as has already been stated, has brought with it such difficulties and distress to the whole world; if only the second solution become an established fact, it would be sufficient to assure the vitality of the greater part of the secondary railways.

Their position is so serious, however, at the present time, that the slightest aggravation of the crisis or any further decline in traffic would be enough to

make their plight practically hopeless.

In most cases, in fact, the Companies operating secondary railways have already cut down their expenditure in many ways by reductions in staff, or in their technical and business organisation, so that any further reduction in receipts would ruin them.

As far as road competition is concerned, in most cases this must be fought with its own weapons; that is to say, diesel or petrol engines must be used upon the railway, and fast light trains must be run at sufficiently frequent intervals, with the maximum comfort for the passengers.

In the case of goods, it is necessary to make the rates and transport conditions as simple as possible, to lower as much as possible the total cost price of transport, to provide rapid and regular transport, if need be by means of agreements with motor firms for door to door transport, etc., and to assure the best possible connections between the secondary and main-line railways for combined transport services.

The problem which we have examined in this report cannot therefore be solved in any definite manner at a time so uncertain as at present.

It will be necessary to follow the possible developments of the present traffic depression with close attention and to adopt, in the meantime, within the limits of the resources available to each Company, all alterations, simplifications and modernisations such as have been dealt with in this report, which might instil new life into the system concerned; to profit by the possible facilities and financial assistance which the different Governments may grant to keep alive such transport organisations; and to await with confidence the end of this difficult period.

Finally, we hope the International Railway Congress Association, Brussels, will keep this problem on its agenda for the next Congress, in 1938, as it is of very great importance that such an important part of the railway communications be kept in being.

Rome, December 1934 — XIII.

Note on Train Speeds,

by LIONEL WIENER,
Professor at the University of Brussels.

PART II *(Continued).* [1]

Train speeds and services in different countries.

VI. — ITALY.

SUMMARY.

CHAPTER XXIX.

The railway system.

XXIX-1. — **General**. — The geographical features of Italy are so marked that they have determined the location of her great railway lines to a greater extent than in other countries.

One has only to follow the peculiar development of the coast line, note the position of those great barriers, the Alps and Apennines, and trace the course of the Pô through the Lombardian plains, to know at first sight where the great railways forming the backbone of the country's system would be situated. The position of the large towns has, in addition, been influenced by historical tra-

---

(1) Cf. *Bulletin of the International Railway Congress Association*, October and November 1933 (pp. 885 and 1027); January, May, June and July 1934 (pp. 63, 407, 561 and 653); February and March 1935 (pp. 141 and 275).

ditions through which the country has been divided up according to its natural boundaries.

The outcome is that, apart from the coast and the Pô railways, most of the main arteries have heavy gradients and long tunnels which fully justify their electrification. Moreover, the fact that the Alps can only be crossed at certain definite points has affected the whole trade of the country and directed the traffic currents between Italy and her neighbours.

Across the North of the country, international transit traffic uses the same routes to enter and leave the country: the coast, the Tende pass, Mount Cenis, and the Simplon, on the one side, and the St. Gothard, the Brenner, and the Semmering on the other.

XXIX-2. — **Transapennine lines** (fig. 158). — Eleven main lines (two of which are duplicated) and three less important ones cross the Apennines; four of these lines run directly from coast to coast.

Fig. 158. — Location of the transapennine lines.

CHIEF FEATURES OF THE TRANSAPENNINE LINES.

Origin			Starting point			Highest point			Ending at		
Place.	Distance. Km. (Miles.)	Altitude. Metres (Feet.)	Place.	Distance. Km. (Miles.)	Altitude. Metres (Feet.)	Place.	Distance. Km. (Miles.)	Altitude. Metres (Feet.)	Place.	Distance. Km. (Miles.)	Altitude. Metres (Feet.)
...	...	...	Battipaglia.	0	68 (223')	Tito.	81 (50.3)	792	Metaponto.	199 (123.6)	4 (13')
...	...	...	Avellino.	0	302 (990')	Nusco.	54 (33.5)	672 (2 598')	Rochetta.	119 (73.9)	218 (715')
Naples.	0	13 (43')	Benevento.	97 (60.3)	122 (403')	Plan. d'Ariano.	140 (87.0)	547 (1 794')	Foggia.	198 (123.0)	64 (210')
...	...	...	Do.	...	...	Baranello.	76 (47.2)	709 (2 326')	Termoli.	172 (106.9)	25 (82')
Rome Term.	0	58 (190')	...	...	...	Avezzano.	108 (67.1)	704 (2 280')	Pescara Cent.	240 (149.1)	5 (16')
(Rome Term.)	0	58 (190')	Orte.	84 (52.2)	52 (170')	Gaifana.	195 (121.2)	494 (1 620')	Falconara.	286 (177.7)	3 (10')
...	...	...	...	...	...	...	...	...	(Ancona.)	197 (122.4)	2 (6 1/2')
(Florence).	0	48 (157')	Prato.	17 (10.6)	63 (207')	S. Benedetto.	57 (35.4)	316 (1 036')	Bologna C.	97 (60.3)	44 (144')
Do.	0	48 (157')	Do.	...	...	Pracchia.	59 (36.7)	616 (2 021')	Do.	133 (82.6)	44 (13')
Do.	0	48 (157')	...	...	...	Fornello.	49 (30.4)	537 (1 761')	Faenza (Ravenna)	101 (62.7)	34 (111')
(Sarzana.)	0	16 (52')	S. Stefano.	8 (5.0)	28 (92')	Borgotora.	55 (34.2)	412 (1 351')	Fidenza.	118 (73.3)	74 (243')
Genoa P. P.	0	16 (52')	Sampierdarena.	4 (2.5)	9 (29')	Busalla.	26 (16.2)	360 (1 181')	Voghera.	83 (51.6)	97 (318')
...	...	...	...	...	...	...	...	...	Millano.	149 (92.6)	127 (417')
Do.	...	...	Do.	...	...	Mignaneno.	23 (14.3)	227 (745')	Do.	...	...
Do.	...	...	Do.	4 (2.5)	9 (29')	Campo Ligure.	29 (18.0)	355 (1 164')	Ovada.	43 (26.7)	196 (643')
...	...	...	...	...	...	...	...	...	Asti.	104 (64.6)	117 (384')
Savona.	...	...	...	0	9 (29')	Sale Langhe.	39 (24.2)	473 (1 552')	Ceva (Turin).	45 (28)	387 (1 270')

Most of these railways have been electrified. The northern ones starting from Savona, Genoa, San Stefano, and Florence (via Pistoja) were all electrified between 1928 and 1932, on the three-phase 3 700-volt 16 2/3-cycle system.

The Rome-Sulmona section, 172 km. (106.9 miles) long, of the Pescara line, was electrified using low-tension (650-800 volt) D.C.

The Naples-Benevento and Foggia line (1928), as well as the new « Direttissima » from Bologna to Florence, including the old section from Prato to Florence, converted in 1934, use high-tension (3 000-volt) D.C.

The physical conditions of two of these relatively old lines were too difficult, even for electric traction. Both of them have been duplicated by new lines including lengthy tunnels, so as to remain at a lower level.

THE BOLOGNA-FLORENCE LINE. — This, the first line across the Apennines, was famous for its location and the number of its tunnels [1], but a « direttissima » (fig. 159), the chief features of which are shown in table 161, has now taken its place.

TABLE 161.

BOLOGNA AND FLORENCE LINE.

Via		Faenza.	Pistoja.	S. Benedetto.
Actual length	km.	150.4	131.8	96.9
	miles	(93.4)	(81.9)	(60.2)
Virtual length	km.	250.0	219.5	124.5
	miles	(155.3)	(136.4)	(77.3)
Length in tunnels	km.	23.744	18.475	36.806
	miles	(14.73)	(11.50)	(22.87)
Maximum gradients in the open		1 in 43	1 in 38.2	1 in 83
Maximum gradients in tunnels		1 in 40	1 in 38.3	1 in 125
Minimum radius of curves	m.	300	300	600
	chains	(15)	(15)	(30)

Although the new line, in comparison with the old, only shortens the journey by

26.5 % (35 km. = 21.7 miles) in actual length,

43.2 % (95 km. = 59.0 miles) in virtual length,

the power consumption is less by 48 % in the case of traffic to the south, and 38 % in the case of traffic to the north, as the trains had to climb 294 m. (965 feet) higher up on the old line.

The summit is reached in the great

[1] There are nearly 10 km. (6.2 miles) of tunnels between Cataldera (altitude + 544 m. = 1 785 feet) and Pracchia (altitude + 616 m. = 2 021 feet). The Apennine tunnel, immediately before reaching the summit, is 2 727 m. (1.7 mile) long, the line rising in it from 544 m. to 616 m.

tunnel at 322 m. (1 056 feet) instead of the previous 616 m. (2 021 feet) above datum. To make this possible it was necessary to drive three long tunnels :

Monte Adona.	Pianoro (N.).	
Pian di Setta.	Grizzana.	
Great tunnel.	Vernio.	

Vado (S.)	7 135 m.	(4.43 miles)
S. Benedetto	3 046 m.	(1.89 miles)
Do.	18 510 m.	(11.50 miles)

journey time from 5 hours to 3 h. 30 m., and to work the service with 23 new electric locomotives instead of the 56 steam locomotives formerly used.

Fig. 159 (*). — Railway lines between Bologna and Florence.

58 km. (36 miles) of the new line being on the straight, the journey time has been reduced from 146 to 66 minutes, and shortly will be further reduced to 59 minutes, as the authorised speed on the Bologna side is 120 km. (75 miles) and on the other, 100 km. (62 miles) an hour.

Electrification of the Naples-Foggia line has made it possible to reduce the

GENOA AND RONCO LINES. — The first line from Genoa to Ronco via Busalla, which should have been completed in 1853, had 1 in 26 gradients. How the trains were to be hauled up this line when completed had not been considered, any more than in the case of the Semmering line which was being constructed at the same time. Since then, various improvements have taken place and the maximum gradients reduced to 1 in 28.5 in the open, and 1 in 34.4 in the tunnels. The Giovi tunnel just before Busalla (254th to 258th km.), which is 5 259 m. (3.27 miles) long [1] is on a 1 in 33 gradient.

Electrification was insufficient to cope with the traffic, so an entirely new line, which is no longer, though its gradients are easier, was built further west, through Campasso and Rio Polcera.

Electrification on the three-phase system has been extended as far as Voghera, where all trains stop five minutes to change engines.

XXIX-3. — Transalpine lines. — The great Alpine barrier, a wide half-circle 1 200 km. (745 miles) in development, and 200 km. (124 miles) deep on the average, is crossed by 8 railway lines. Luckily these mountains are not impre-

(*) Figures 159, 160 and 161 are reproduced from *The Railway Gazette*.
(1) Mauss rock drilling machines and twin locomotives, the first of which were built by Cockerill, of Seraing, were used for the first time here.

TABLE 162.

CHIEF FEATURES OF THE TRANSALPINE LINES.

Origin			Beginning of gradient			Maximum altitude			End of gradient		
Place.	Distance. Km. (Miles.)	Altitude. Metr. (Feet.)	Place.	Distance. Km. (Miles.)	Altitude. Metr. (Feet.)	Place.	Distance. Km. (Miles.)	Altitude. Metr. (Feet.)	Place.	Distance. Km. (Miles.)	Altitude. Metr. (Feet.)
...	...	...	Ventimiglia.	0	11 (36')	Limone.	68 (42.3)	1 002 (3 287')	Coni. (Turin).	100 (62.1)	502 (1 647')
										188 (116.8)	239 (784')
(Turin).	0	239 (784')	Bussoleno.	46 (28.6)	440 (1 443')	Bardonecchia.	88 (54.7)	1 258 (3 963')	In France.		
						Modane.	106 (65.9)	1 056 (3 464')			
(Milan).	0	127 (516')	Domodossola.	125 (77.7)	271 (889')	...	...	...	In Switzerland.		
Milan.	0	127 (516')	Chiasso.	51 (31.7)	238 (781')	...	...	...	In Switzerland.		
(Verona).	0	64 (210')	Bolzana.	148 (92.0)	266 (873')	Brennero.	237 (147.3)	1 370 (4 495')	In Austria.		
Do.	Do.	Do.	Fortezza.	196 (121.8)	747 (2 450')	Dobbiaco.	257 (159.7)	1 210 (3 970')	S. Candido.	261 (162.2)	1 177 (3 861')
									In Austria.		
(Venice).	0	4 (13')	Udine.	136 (84.5)	108 (354')	Camporosso.	225 (139.8)	804 (2 638')	Tarvisio.	230 (142.9)	731 (2 398')
Trieste.	1 (0.6)	3 (10')	...	...	...	Postumia.	82 (51.0)	582 (1 910')	Fusine.	239 (148.5)	848 (2 782')
									...	...	...

gnable and are relatively easily reached from the Pô plains along gradually rising valleys through which the Cenis, Simplon ,and St.Gothard lines are carried.

The MOUNT CENIS LINE is the oldest of them (1871) and was used for both the Franco-Italian and the Anglo-Italian traffic (¹). Correctly speaking, the tunnel is wrongly named, as the line is carried under the Monte Leone, Mount Cenis being 27 km. (16.8 miles) further east.

While the tunnel was driven, a temporary line was laid over the mountain, on the *Fell* system (²).

The Mount Cenis line has been electrified on both sides. On the French side, the gradients are 1 in 40, while on the Italian, they reach 1 in 33.

The boring of the Saint-Gothard tunnel considerably affected the Mount Cenis line, both politically and economically, as it facilitated communications between Italy on the one hand, and Belgium, Holland and Germany on the other. This fact was appreciated to such an extent that the countries most directly concerned largely subsidised the scheme (³) and, in exchange, the additional charges above the Swiss tarif applicable to this mountain line were reduced by agreement.

Access to the Simplon tunnel only took place from the Rhône valley. Although a great portion of the tunnel was on Italian soil, the Swiss *Jura-Simplon* Company and afterwards its successor, the *Swiss Federal Railways,* carried out the whole of the constructional work, and not only operated the Italian part of the line, but also the Isella-Domodossola section which had been built by the *Italian State* Railways (⁴).

The approach gradient on the Italian side necessitated much constructional

---

(¹) The road built by Napoleon, which reached an altitude of 2 182 m. (7 160 feet), included nevertheless a 1 330-m. (0.82 mile) tunnel. at the Arc de Modane.

Work on the tunnel started in 1857; it was completed at the end of 1870, and opened to service on the 16th October 1871.

(²) This line, 73 km. (45.4 miles) long, from Saint Michel (*P.L.M.*) to·Susa (station on the former *Alta Italia*), at Lanslebourg reached an altitude of 1 775 m. (5 823 feet). The line was of 1.10-m. (3 ft. 7 5/16 in.) gauge, the radius of curves as small as 48 m. (157 feet) and the gradients as much as 1 in 14.

The time taken by the trains was 3 h. 45 m.

The line was opened in October 1867, and was closed when the tunnel was completed, but it was the prototype of similar lines since built in other countries.

(³) The subsidies were originally contributed as follows : Germany (Northern Germany, Baden and Wurtemberg) 20 000 000 gold-francs, Switzerland, the same amount, and Italy 45 000 000. Actually, Germany had to contribute 30, Switzerland 31, and Italy 58 million gold-francs.

The agreement was signed on the 15th October, 1869. Work began in 1872, and the line was opened to traffic on the 1st June, 1882.

(⁴) This tunnel is 19 303 m. (12 miles) long, 10 719 m. (6.64 miles) being in Italy. The 11 km. (6.8 miles) from the southern end to Isella, and the 19 km. (11.8 miles) on to Domodossola are operated by the *Swiss Federal* Railways.

Begun in 1898, the tunnel was driven by the 24th February 1905, and opened to traffic on the 1st June 1906.

work, including 8 067 m. (5 miles) of tunnel between Isella and Domodossola. The Varzo helicoidal tunnel ([1]) (fig. 160), (1 968 m. = 1.22 miles) on a 1 in 55 gradient, is immediately followed by the Trasquera tunnel (1 712 m. = 1.06 miles) on a 1 in 53 gradient. On the open track, the maximum gradient is 1 in 40.

The BRENNER PASS railway, the highest of all the transalpine lines, was built without any tunnel at all, though it reaches an altitude of 1 368 m. (4 488 feet).

TUNNEL.	Length.	Maximum altitude.	Surface altitude.	Date of construction.
Cenis	12.220 km. (7.58 miles)	1 338 m. (4 390 ′)	2 949 m. (9 676 ′)	1857/1871
Gothard	14.984 km. (9.3 miles)	1 154 m. (3 786 ′)	2 861 m. (9 387 ′)	1872/1881
Arlberg	10.260 km. (6.34 miles)	1 310 m. (4 298 ′)	1 775 m. (5 824 ′)	1880/1884
Brenner	0 m.	1 368 m. (4 488 ′)	1 368 m. (4 488 ′)	...

The two slopes are on opposite sides of the new Austro-Italian frontier. On the Austrian side, the line is electrified throughout, while on the Italian side electrification only covers the 90 km. (56 miles) to Bolzano (Brixen). It is to be continued towards the south as far as Bologna, and ultimately to Rome.

The TENDE PASS line, the most recent of the transalpine lines, crosses the range at its southern end, and links up Venti-miglia and Nice with Coni (Cuneo) and Turin, beyond.

Owing to the crookedness of the frontier, this railway has a unique feature; the French line burrows under a corner of Italy which includes Mount Grazian, while the Italian extension of the same line crosses part of France between S. Dalmazzo di Tenda and Piena. At Breil, an international station on French territory, it separates into two branches which run through tunnels ([2]) which cross

([1]) The spiral has a radius of 195 m. (640 feet). The difference in level between the ends of the tunnel is 93 m. (305 feet).

([2]) With the following features :

LINE.	Coni-Breil.	Breil-Nice.	Breil-Ventimiglia.
Maximum altitude	1 040 m. (3 411′).	418 m. (1 371′). (Tende Pass).	305 m. (1 000′),
Actual length . . . . Length underground	(78 km. (48.5 miles). 5.380 km.(3.34 miles) in France.	45 km. (28 miles). 16.143 km. (10.0 miles).	22 km. (13.7 miles). 1.742 km (1.08 miles in France.
Maximum gradient . . . . . Gradient underground . . . . Minimum radius of curves . . .	... ...	1 in 40. 1 in 40 and 1 in 47. 300 m. (15 chains).	1 in 40. ... ...

Fig. 160. — Varzo spiral tunnel (Milan-Domodossola line).

twice. A number of others also have points of interest [1].

The opening of the French section [2] has considerably shortened the train jour-

[1] The list is as follows :

TUNNEL.	Length.	Remarks.
Italian trunk line.		
S. Dalmazzo	...	Winding.
Briga.	...	Spiral.
Italian branch.		
Carpo Berta	2.432 km. (1.51 miles).	Between Diario Marina (101st. km.) and Onaglia (107th. km.)
French branch.		
Braus Pass.	5.939 km. (3.7 miles).	On the straight.
Mount Grazian.	3.887 km. (2.42 miles).	On the straight under Italy but with the two portals in France.
Caranca	0.916 km. (0.57 mile).	Curved.
Do.		Curved. Italian section (in France).
Berghe . . . . . . ,. . .	1.885 km. (1.17 miles).	Spiral.

The Italian branch rises continuously from an altitude of 10 m. (33 feet) at Ventimiglia to 226 m. (741 feet) at Piena (165th. km.), and includes, between these two stations, 17 tunnels with a total length of 7.741 km. (4.8 miles).

The French branch includes 45 tunnels with a total length of 23 km. (14.3 miles).

[2] The French branch, authorised in 1906 and contracted out in 1909, was begun in 1924, and completed in 1928.

ney between Nice and Turin to Berne and Basle, and the construction of the Italian section of the line has improved the service between San Remo and Geneva. The distance from Berne to Nice used to be 902 km. (560.4 miles) via Lyons; it has been reduced to 592 km. (367.9 miles) by the Lötschberg and Turin line.

The French branch includes 45 tunnels with a total length of 23 km. (14.3 miles).

Both sections of the Italian line have been electrified : to the South, between Ventimiglia and Piena as an extension of the line coming from Pisa and Genoa and to the North, from S. Dalmazzo di Tenda to Coni (58 km. = 36 miles). The 24 km. (14.9 miles) separating these two sections, which lie in France, are not electrified.

Lines on the Southern side of the Alps. — Apart from the lines running right through the Alps, a number of railways do not cross the range. These are mostly standard or narrow-gauge regional lines.

The AOSTA VALLEY RAILWAY ([1]), between mountains more than 3 000 m. (9 840 feet), high, is electrified on the 3 000-volt D.C. system.

The DOLOMITES RAILWAY ([2]) uses D.C. at 2 700 volts. The maximum speed of the trains is 45 km. (28 miles) an hour.

XXIX-4. — **Alternative lines.** — As in Holland, the amalgamation into a single administration of the former separate *Mediterraneo* and *Adriatica* Companies often brought the *Italian State* Railways two different lines between the same places. But, unlike what happened in Holland, the Italian railways have concentrated all important traffic on one of the alternative routes and relegated the other to the rank of a regional line.

Fig. 161 (*). — Old and « direttissima » lines between Rome and Naples.

Then, too, some of the old mountain lines, such as those from Genoa to Ronco, Florence to Bologna, and Rome to Naples, were badly located. Entirely new « di-

---

([1]) This standard-gauge railway is 31 km. (19.3 miles) long from Aosta (altitude 573 m. = 1 880 feet) to Pré Saint-Didier (altitude 1 004 m. = 3 294 feet).

The maximum gradients are 1 in 33, the minimum radius of curve is 150 m. (7 1/2 chains).

The Grande Rochère (altitude 3 326 m. = 10 910 feet) lies to the North of the line, and Mount-Calmet (3 024 m. = 9 920 feet) to the South.

([2]) The 65 km. (40.4 miles) of 0.95-m. (3 ft. 1 3/8 in.) gauge line from Calzo (alt. 806 m. = 2 644 feet) to Dobbiaco (alt. 1 210 m. = 3 970 feet) crosses the summit at an altitude of 1 528 m. (5 012 feet).

The weight of a train hauled by a motor vehicle is 73 or a maximum of 85 tons; hauled by an electric locomotive, the train may be made up to 150 tons.

rettissima » lines have been built in their place serving new localities, the old lines being retained for local traffic only.

The Rome-Naples « Direttissima » (figs. 161 and 162) via Formia is 215.788 km. (134.1 miles) long, i.e. 33 km. (20.5 miles) less than the old line via Cassino, and 70 km. (43.5 miles) less in virtual length. To obtain high speeds, it was found possible to locate the line in such a way that 174 km. (108.1 miles) were on the straight; these include the 10.822 km. (6.72 miles) section from Campoleone to Cisterna and the 16.684 km. (10.4 miles) section between Carano and Falciano.

The Monte-Orso tunnel alone is 7.530 km. (4.68 miles) long; but altogether there are 16.684 km. (10.4 miles) of tunnels.

This new railway was opened to traffic on the 30th October 1927 and the journey from Rome to Naples was reduced from 4 h. 25 m. to 2 h. 50 m.

XXIX-5. — Competing lines. — The only internal competition to be found in Italy is between the *Nord Milano* and the *State Railways* in the outer suburbs of Milan.

Where secondary lines link up places also served by the *State* Railways, they only serve local interests, whereas the through traffic is handled by the *State* Railways.

The Nord Milano Ry. Co. (fig. 163) has electrified its system ([1]) including the

---

([1]) The trains include a motor coach and a trailer with driving compartment, weighing together 108 tons. For express or through trains, one or two trailers are added which bring the weight up to 143 or 178 tons. The rail motor coaches have bodies 20.60 m. (67 ft. 7 in.) long with 24 1st-class, 54 second-class seats, and standing room for 100 in addition to 11 tip-up seats. They weigh 53 tons empty and 62 in service.
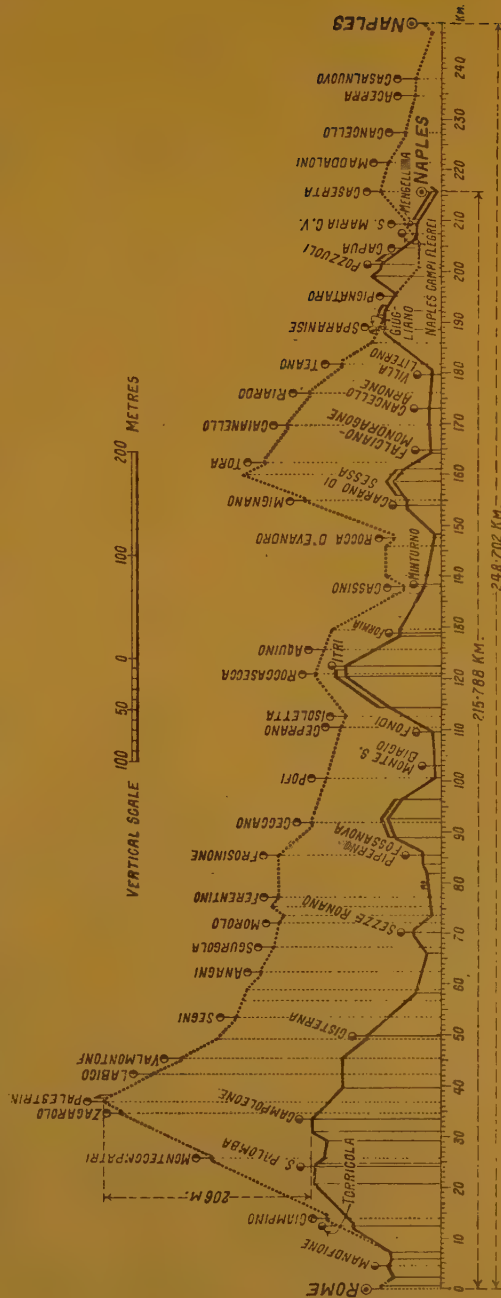

Fig. 162. — Gradient section of the Rome-Naples lines.

TABLE 163.

ALTERNATIVE OR COMPETING LINES.

RUN.			Distance.		Time of departure.	Time spent.	Speed.		
Origin.	(Via)	Destination.	Km.	Miles.			Km./h.	Miles/h.	
Alternative lines.									
Milan C.	Bologna-Florence / Genoa-Pisa / Fidenza-Fornovo	Rome	632 650 621	393 404 386	R 10.30 a. m. 12.10 p. m. 10 20 p. m.	8.10 9.45 8.35	77.2 66.7 72 3	47 9 41.4 44.9	Rapido. All-sleeping-car train.
Rome	Formia-Aversa) Naples C. / Cassino { Do. / Formia ·) Naples Merg.	. . . .	214 249 210	133 155 131	8.15 p. m. 7.20 a. m. 9.50 a. m.	3.16 5.35 2.45	65.5 44.5 76.4	40 7 27.7 47.4	
Rome	Vill.-Lit.-Caserta-Foggia { Vill.-Lit.-Naples-Metaponte	Brindisi .	607 600	377 373	12.25 p. m. 4.50 a. m.	10.45 14.14	37.9 32.7	23.6 20.3	
Bologna	S. Benedetto } Pistoja {	Florence	97 133	60 81	9.37 a. m. 9.37 a. m.	1.06 3.03	88.2 43.6	54.8 27.1	Rapido.
Competing lines.									
Milan	Gallarate } Saronno {	Laveno.	76 73	47 45	6.50 p. m. 5.38 p. m.	1.22 1.18	55.6 56 2	32.7 35.0	State Rys. N. Milano.
Milan	Gallarate } Saronno {	Varese.	60 51	37 32	9 01 a. m. 5.38 p. m.	0.41 1.48	87.8 28.3	54.6 17.6	State Rys. N. Milano.
Milan	Monza } Saronno {	Como	47 40	29 25	1.10 p. m. 5.30 p. m.	0.43 0.51	70.0 47.0	43.5 29.2	State Rys. N. Milano.

4.190 km. (2.6 miles) trunk section which carries heavy traffic between Milan and Bovia where it splits into two branches, running to Saronno and to Meda (¹).

The *State Railways* also have a trunk line running to Gallerate where it separates into three branches running to the several lakes of the district :

Milan-Gallerate		40.3	km. (25 miles)	1 in 166
Gallarate to { Arona	Lago Maggiore..	26	km. (16.2 miles)	1 in 91
{ Laveno	Do.	31	km. (19.3 miles)	1 in 125
(Varese and Porto Ceresio.	Lago di Lugano.	33	km. (20.5 miles)	1 in 50.

Electrification took place long ago and the Varese line now is the fastest in Italy. Gradients increase slightly as it climbs the valley (fig. 164), the maximum gradient reaching 1 in 250 as far as

Rho, 1 in 166 as far as Gallarate, 1 in 83 as far as Varese, and 1 in 50 beyond.

The ROME-VITERBO electric railway, via Civita Castellana, took the place of a former tramway (²). Comparative dist-

---

(¹) D.C. at 3 000 volts.

(²) *Sta Romana per le Ferrovie del Nord*, whose line replaced as from the 27th October,

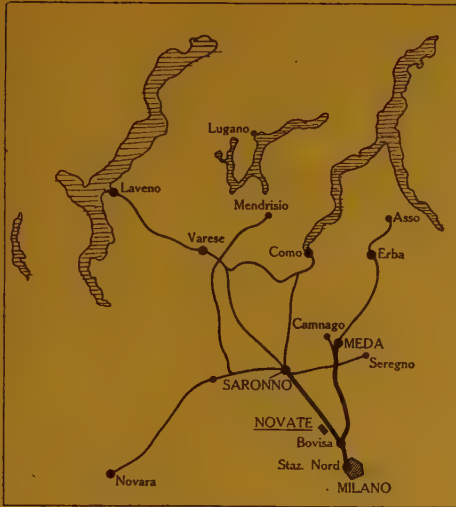1934, the former tramway line built in 1905, 3 000-volt D.C.

Fig. 163. — Railway system
of the Nord Milano Co.

ances and journey times by the State
Railways and this Company were as fol-
lows :

Rome—Civita Castellana—Viterbo (*Company*)
102 km. (63.4 miles), 2 h. 14 m., 27 stops.
Rome-Capranica-Sutri-Viterbo (*Italian State*)
96 km. (59.6 miles), 2 h. 3 m., 8 stops.
(A trains.)

International competition. — Rome,
Milan, and to a lesser extent, Genoa, are
coveted objectives of international com-
petition by the Mount-Cenis, the Simplon,
and the St. Gothard routes, whose inte-
rests differ greatly.

The *Paris-Lyons and Mediterranean
Ry.* serves two of these objectives, its
lines being respectively 673 and 463 km.
(418.2 and 287.7 miles) long, while the
Est Ry. connects with the last two only :
(the Lötschberg and St. Gothard lines) [1].

(1) The distance from Paris Est to Delle is
465 km. (288.9 miles). Its share in the
north-east transverse line between Laon and
Delle is 446 km. (277.1 miles).
The trains run towards the St. Gothard via
Basle following the *Est* system for a distance
22 km. (13.7 miles) shorter. To this must be
added, however, a distance of 83 km. (51.6
miles) over the *Alsace-Lorraine* system.
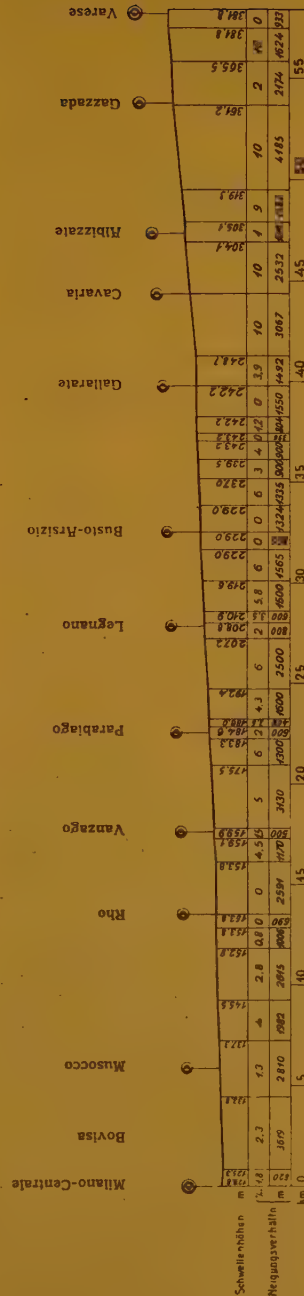
Fig. 164. — Gradient section of the Milan-Varese line.

Note. — Schwellenhöhen = Altitudes. — Neigungsverhälten = Gradients.

TABLE 164.

ANGLO- AND FRANCO-ITALIAN SERVICES BY THE DIFFERENT COMPETING LINES.

JOURNEY VIA	MOUNT CENIS.				SIMPLON.				ST. GOTHARD.			
	Time of departure.	Time spent.	Distance. Km.	Miles.	Time of departure.	Time spent.	Distance. Km.	Miles.	Time of departure.	Time spent.	Distance. Km.	Miles.
Calais-Rome .	5.35 p. m.	26.15	1 760 (1)	1 093.6 (1)	5.35 p. m.	28.55	1 878	1167.0	8.30 p. m.	26.00	1 786	1 109.8
Paris-Rome .	10.00 p. m.	21.50	1 446	898.5	10.40 p. m.	23.50	1 453	902.9	10.00 p. m.	24.30	1 527	948.8
Calais-Milan .	2.50 p. m.	23.02	1 246 (1)	774.2 (1)	5.35 p. m.	19.05	1 121	696.5	8.30 p. m.	17.10	1 154	717.1
Paris-Milan .	11.20 p. m.	18.28	932	579.1	10.40 p. m.	14.00	821	510.1	10.15 p. m.	15.40	895	556.1
Calais-Genoa .	5.35 p. m.	19.00	1 259 (1)	682.3 (1)	5.35 p. m.	24.05	1 270	789.2	8.30 p. m.	19.46	1 303	809.7
Paris-Genoa.	10.00 p. m.	14.35	945	587.1	10.40 p. m.	19.06	970	602.7	10.00 p. m.	18.16	1 044	648.7

(1) Via Paris *Nord* and Paris *P.L.M.* (15 km. = 9.3 miles).

The *Nord* shares to an equal extent in each case ([1]).

On the other hand, the *Swiss Federal* Railways have no interest in the Mount Cenis line. The length of the Swiss section of the Simplon line is 238 km. (147.9 miles) ([2]), of the St. Gothard over 320 (198.8 miles), and of the Lötschberg, 233 (144.8 miles) from Delle, and 234 (145.4 miles) from Basle ([3]); but 125 km. (77.7 miles) of this line only is operated by the *Swiss Federal* Railways, the balance belonging to the *B.L.S.*

Thanks to the high speed maintained on the North-East French transverse line, the fastest in the world, the difference in time taken for the journey from Paris to Rome by the Simplon or St. Gothard routes is less than a quarter of an hour, but the Mount Cenis route is the quickest of the three.

The Simplon route to Milan is the fastest from Paris, and the St. Gothard line the quickest from Calais (and London). As for Genoa, the best time is achieved by the Mount Cenis route, the saving being considerable from Paris, and less so from Calais (and London).

XXIX-6. — Loading gauges (figs. 165 and 167). — Whereas each square inch of the loading gauge is precious in order to cover all the parts of the rolling stock,

---

([1]) The trains run over the *Nord* system for 299 km. (185.8 miles), then rejoin the *P.L.M.* or the *Est* by one of the *Ceinture* lines. The trains using the North-East transverse line cover 274 km. (170.3 miles) on the *Nord* system.

([2]) To be exact, 192 km.. (119.3 miles) in Switzerland plus 43 km. (26.7 miles) from Brig to Domodossola, operated by the Swiss Federal Railways.

([3]) To this must be added the 43 km. (26.7 miles) from Brig to Domodossola.

The distance from Brig to Basle is shorter by only 1 km. (0.6 mile).

any increase in it, no matter how small, makes an extraordinary difference. This is now being taken advantage of in Italy.
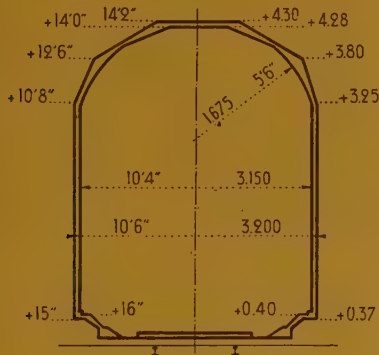
As is known, the international loading

Fig. 165. — Standard and enlarged loading gauges of the Italian Railways.

gauge as formerly fixed by the U.I.C. was 3.10 m. (10 ft. 2 in.) wide; in 1922 it was decided to increase this by 5 cm. (2 inches) between the height of 3.17 m. and 4.30 m. (10 ft. 5 13/16 in. and 14 ft. 6 7/16 in.) above rail level, bringing the width to 3.15 m. (10 ft. 4 in.).

So as to accomplish this, important alterations had to be undertaken and whilst the Italians were at it, they decided to increase the width by 10 cm. (4 inches) instead of 5 only, as very little extra cost was involved thereby.

On curves of 250-m. (12 1/2 chains) radius, this allows vehicles to encroach upon the widened loading gauge by 75 mm. (2 61/64 inches) as the extra width is 100 mm. (4 inches).

The Italian Railways' *Rivista Tecnica* has quoted some striking examples. Thus, with an increase of 10 cm. (4 inches) in the loading gauge, it has been found possible to lengthen the bodies of the usual types of vehicle [1] by more than 4 m. (13 ft. 1 1/2 in.).

The new all-metal coaches (fig. 166) use 2.17 m. (7 ft. 8 1/2 in.) of this additional length. Their chief dimensions are as follows, the dimensions of the old coaches being given in italics for comparison purposes (table 165).

With 3.50 m. (11 ft. 5 25/32 in.) overhang and 17 m. (55 ft. 91/4 in.) between bogie centres, the body can be made 54 mm. (2 1/8 inches) wider (52 mm. = 2 1/16 inches at the ends) or, if the same width be kept, it can be made 2 m. (6 ft. 6 3/4 in.) longer.

In Italy, the standard gauge is still usually 1.445 m. (4 ft. 8 29/32 in.) instead of 1.435 m. (4 ft. 8 1/2 in.) as in most other countries. The narrow gauge is generally 0.95 m. (3 ft. 1 3/8 in.) although there are some metre (3 ft. 3 3/8 in.) gauge lines as well.

Figure 167 shows the loading gauges of the narrow-gauge lines in Italy, Belgium and Holland, the track gauges being 0.95 m., 1 m. and 1.067 m. (3 ft. 1 3/8 in., 3 ft. 3 3/8 in. and 3 ft. 6 in.) respectively.

Figure 168 gives in addition the loading gauges of Italian metre and 0.75-m. (2 ft. 5 1/2 in.) lines.

---

(1) The leading dimensions are as follows :

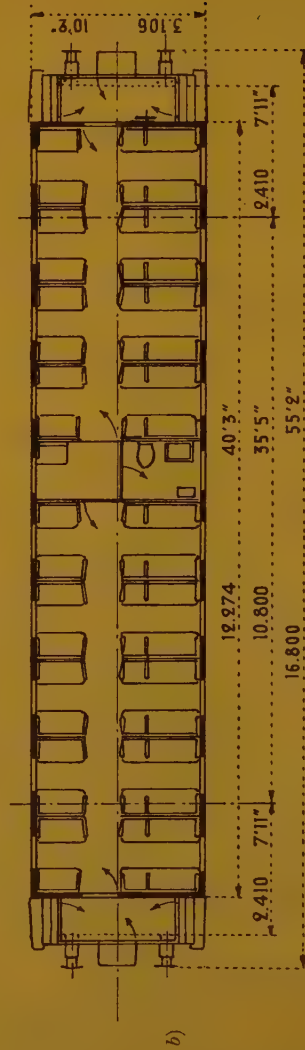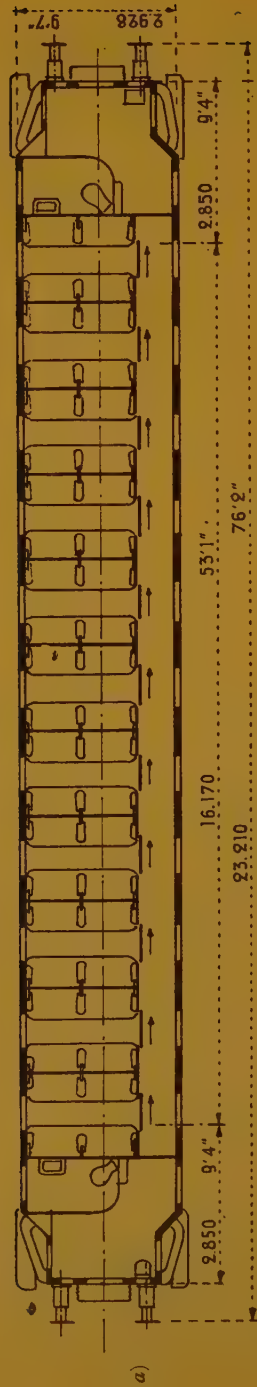|		
Loading gauge width . .	3.100 m. (10 ft. 2 in.)	3.200 m. (10 ft. 6 in.)
Width (uniform)	2.850 m. (9 ft. 4 3/16 in.)	2.850 m. (9 ft. 4 3/16 in.)
Overhang	3.000 m. (9 ft. 10 1/8 in.)	3.650 m. (11 ft. 11 3/4 in.)
Distances between bogie centres	16.158 m. (53 ft. 5/32 in.)	19.000 m. (62 ft. 4 in.)
Maximum length over body.	22.158 m. (72 ft. 8 3/8 in.)	26.300 m. (86 ft. 3 1/2 in.)

Fig. 166. — Recent all-metal coaches.

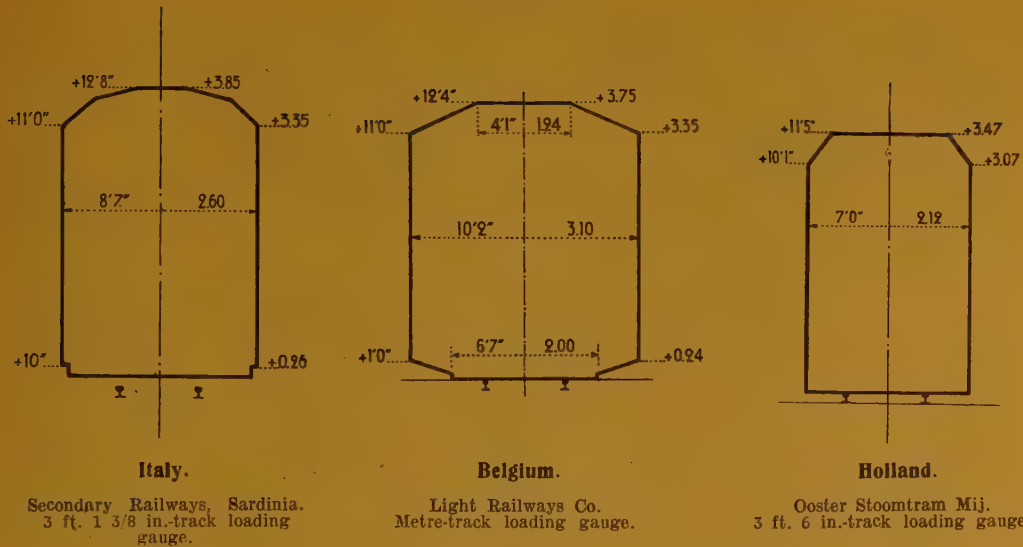a) Long coach. b) Wide coach for lines with enlarged loading gauge.

Fig. 167.

Italy.

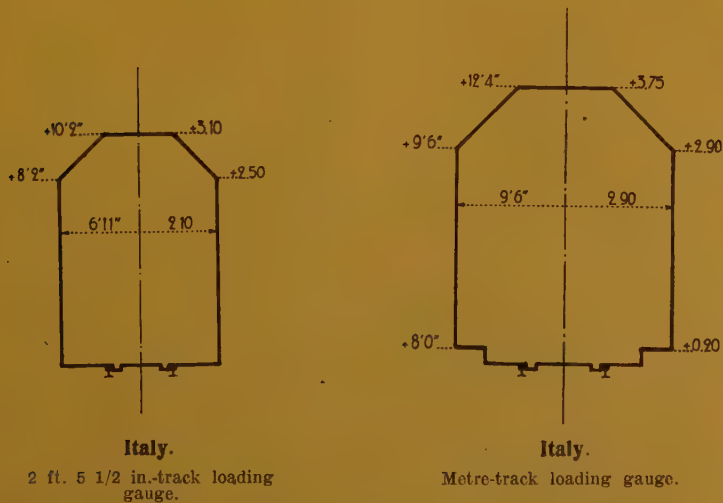Secondary Railways, Sardinia.
3 ft. 1 3/8 in.-track loading
gauge.

Belgium.

Light Railways Co.
Metre-track loading gauge.

Holland.

Ooster Stoomtram Mij.
3 ft. 6 in.-track loading gauge.

Fig. 168.

Italy.

2 ft. 5 1/2 in.-track loading
gauge.

Italy.

Metre-track loading gauge.

Fig. 167 and 168. — Loading gauges of metre and narrow-gauge lines.

The gradients on 0.95-m. (3 ft. 1 3/8 in.) gauge electrified secondary lines reach as much as 1 in 14 (Biella-Oropa, Como-Amandola, Vicenza-Chiampo).

IV—4

TABLE 165.

LEADING DIMENSIONS OF RECENT ITALIAN ALL-METAL ROLLING STOCK.

Length, overall	23.210 m. (76 ft. 1 25/32 in.)		
Do. between headstocks. . .	21.870 m. (71 ft. 9 in.)		
Between bogie centres	16.170 m. (53 ft. 5/8 in.)		
Outside width of body	2.846 m. (9 ft. 4 in.)	2.928 m. (9 ft. 7 9/32 in.)	
Class	1st.	2nd.	3rd.
Compartments : Number . . .	8	9	11
	7	8	10
Do. Length . . .	2.080 m. (6 ft. 29/32 in.)	2.080 m. (6 ft. 9 29/32 in.)	2.080 m. (6 ft. 9 29/32 in.)
	1.971 m. (6 ft. 19/32 in.)	2.035 m. (6 ft. 8 1/8 in.)	2.000 m. (6' 6 3/4")
Do. Width	2.140 m. (7 ft. 15/64 in.)	1.900 m. (6 ft. 2 25/35 in.)	1.540 m. (5 ft. 5/8 in.)
	2.140 m. (7 ft. 15/64 in.)	1.870 m. (6 ft. 1 5/8 in.)	1.481 m. (4 ft. 10 5/16 in.)
Number of passengers carried . .	48	72	88
	42	64	80

CHAPTER XXX.

The trains.

XXX-1. — Express trains. — There are three kinds of express trains : the « diretti », the « direttissimi » and, latterly, the « rapidi » on main lines only (fig. 169) :

Turin-Milan-Genoa-Rome-Naples ;
Milan-Bologna-Florence-Rome ;
Bologna-Verona-Trento-Bolzano (Bozen) ;
Bologna-Padua-Venice-S. L. ;
Milan-Padua-Venice-Trieste ;
Milan-Bologna-Brindisi.

These trains often run long distances without intermediate stops, and have average speeds of over 90 km. (56 miles) an hour. These noteworthy improvements are quite recent. In a few instances, the speeds were set to high, and a couple of the 1933 timings have had to be eased out. Thus, 14 minutes had to be added between Milan and Venice, and 10 minutes between Rome and Naples.

In 1933, the fast trains hauled by 2-6-2 locomotives weighed 300 t. (295 Engl. tons), even in the case of journeys across the Apennines and Maritime Alps. Others on the Milan-Bologna line, headed by *Pacific* locomotives, weighed as much as 350 t. (344 Engl. tons). The Rome and Naples (Mer.) and the Milan and Venice expresses are lighter and weigh only 210 and 230 t. (207 and 226 Engl. tons) respectively.

Boat trains. — Apart from the *Sleeping-Car Company's* trains, dealt with hereafter, the Italian railways run very few boat trains (cf. table 170).

On the other hand, Italy was first to run airplane trains the first of which was run from Rome to Brindisi on the 21st April, 1932, leaving Rome at 6 p. m. and arriving at Brindisi at 3.55 a. m. the next morning. The airplanes left at 5 a. m. and flew to Egypt twice a week (with extensions to the East Indies or South Africa), to Constantinople twice, and to Athens and Rhodes once a week.

XXX-2. — Local trains. — In order to protect their local traffic from road motor encroachment, the railways intro-

TABLE 166.

THE « RAPIDI » TRAINS (fig. 169).
(Non-stop runs shown in **heavy type**.)

RUN.	Distance.		Time of departure.	Time spent.	Speed.		Num-ber of stops.	Train.
	Km.	Miles.			Km./h.	Miles/h.		
Turin-Milan Centrale	153	95.1	5.52 p. m.	1.53	81.2	50.5	1	R93-R99.
Turin P. S.-Milan Cent. .	147	91.3	R 12.20 p. m.	1.46	83.2	51.7		R90-R94.
			12 15 p. m.	1.43	85.6	53.2		R.
Milan-Venice (Sᵃ L.)	267	165.9	11.57 a. m.	2.58	90.0	55.9	2	R91.
Milan-Verona	148	92.0	**Do.**	**1.36**	**92.5**	**57.5**		Do.
Verona-Padua	82	50.9	**1.36 p. m.**	**0.50**	**98.4**	**61.1**		Do.
Padua-Venice Sᵃ L.	37	23.0	**2.27 p. m.**	**0.27**	**82.2**	**51.1**	°	Do.
Milan-Venice	267	165.9	11 35 a. m.	3.04	85.4	53.1	3	R92-R98.
			6.10 p. m.	3.02	88.0	54.7	2	R95.
Venice Sᵃ L.-Trieste	157	97.6	R 9.50 p. m.	2.10	72.4	45.0	1	R75-R76.
			R 4.10 p. m.	**2.12**	**71.4**	**44.4**		R77.
Milan-Genoa	149	92.6	**12.10 p. m.**	**1.57**	**76.4**	**47.5**		R83-R84-R85.
			5.45 p. m.	1.58	76.4	47.5		R86.
(Genoa) Pisa-Rome	336	208.8	5.34 p. m.	4.21	77.2	48.0	1	R.53.
			R 2.05 p. m.	**4.23**	**76.7**	**47.7**		R54.
			3.27 p. m.	3.43	90.4	56.2	1	P. R.
Milan-Bologna-Florence-Rome T.	633	393.3	7.00 a. m.	8.20	76.0	47.2	2	R22-R23-R27.
			11.35 a. m.	8.25	75.2	46.7		R25.
			R 2.15 p. m.	**8.15**	**76.7**	**47.7**		R26.
			R 10 30 a. m.	**8.10**	**77.5**	**48.2**		R24.
Milan-Bologna	219	136.1	7.00 a. m.	2.30	87.6	54.4		
Bologna-Florence	97	60.3	9.37 a. m.	1.06	88.2	54.8		
Florence-Rome	316	196.4	R 7.15 p. m.	**4.18**	**73.5**	**45.7**		
Milan-Bologna-Brindisi . . .	980	608 9	12 30 a. m.	15.19	63.9	39.7		P. E.
Milan Cent.-Bologna . . .	219	136.1	**Do.**	**2.46**	**79.2**	**49.2**		Do.
Bologna-Rimini	112	69 6	3.25 a. m.	1.22	81.9	50.9		
Rimini-Ancona	90	55 9	4.52 a. m	1 18	70.0	43.5		Do.
Ancona-Pescara Cent. . . .	240	149.1	6.16 a. m.	2.32	94.7	58.8		Do.
Pescara Cent.-Foggia . . .	177	110.0	8.53 a. m.	2.58	60.0	37.3		Do.
Foggia-Brindisi Cent. . . .	123	76.4	11.56 a. m.	1 50	67.1	41.7		Do.
Bologna-Florence-Rome Term.	414	257.2	6.15 p. m.	5 55	70.0	43.5	2	R29.
			R 7.15 p. m.	**5.24**	**75.0**	**46.6**	1	R28.
Bologna-Florence-Rome Tev.			3.25 a. m.	5.34	74.4	46.2	cond.	P. N.
Rome Tev.-Naples Cent. . .			9.05 a. m.	2.38	81.3	50.5		P. N.
Bolzano-Gries-Bologna Cent. .	261	162.2	2 34 p. m.	3.23	77.1	47.9	2	R67.
			R 1.15 p. m.	**3.56**	**66.3**	**41.2**	2	R66.
Bolzano-Trento	55	34.2	**2.34 p. m.**	**0 40**	**82.5**	**51.3**		R67.
Trento-Verona	92	57.2	**3.15 p. m.**	**1.06**	**83.6**	**51.9**		Do.
Verona-Bologna	114	70.8	**4.27 p. m.**	**1.30**	**76 0**	**47.2**		Do.
Venice S. L.-Bologna	160	99.4	8.00 p. m.	2.06	78 6	48.8	2	R76.
			R 12.05 p. m.	**2.00**	**80.0**	**49.7**	2	R75.
Padua-Ferrara	76	47.2	**12.34 p. m.**	**0.54**	**84.8**	**52.7**		R75.
Ferrara-Bologna	47	29.2	R 8.00 p. m.	**0 35**	**80.6**	**50.1**		R76.
Rome Term.-Naples Mergelina .	210	130.5	9.50 a. m.	2.45	76.4	47.5		R51-R52-R56.
Rome Term.-Naples Cent. . .	214	133.0	7.25 p. m.	2.40	80.0	49.7		
Rome Tev.-Naples Maritima . .	221	137.3	9.05 a. m.	3 05	71.7	44.6		R55.
Rome Tev.-Naples Cent. . . .	Do.	Do.	2.38 a. m.	81. 3	Do.	Do.	1	P. N.
Naples Cent.-Naples Maritima	11.51	7.15	12.19 a. m.	22. 1	Do.	Do.		

Fig. 169. — Italian « rapidi » (fast express) train routes.

Legend : see fig. 176, page 421/429.

duced, in addition to the mixed trains and locals, two series of trains consisting of a couple of coaches weighing 65 to 70 tons drawn by a small locomotive. These are known as « accelerated trains » and « A accelerated trains »; they stop for 30 seconds at the most, at every station and wayside stopping place; their running speed is as high as 70 km. (43.5 miles) an hour. In spite of such numerous stops, they are faster than the former services, for example :

	Km.	Miles.				
Aqui-San Guiseppe . .	50	(31.0)	72	minutes	instead of	123
Trento-Verona	92	(57.2)	112	»	»	152
Pisa-Empoli-Florence .	81	(50.3)	68	»	»	120.

XXX-3. — Perishable-goods trains (fig. 170). — In order to help fruit and vegetables exports, a considerable amount of fixed plant has been installed on the initiative of the National Export Office, and in a very short time, this has led to a notable development of export trade. At suitable centres, such as Verona, Bologna, Naples, Milan, etc..., cold storage plant has been erected and works in con-

TABLE 167.

EXAMPLES OF THE SPEED OF ACCELERATED AND A. TRAINS.
(Comparative figures relating to other trains *in italics*.)

RUN.	Distance		Time spent.	Number of stops.	Class of train.	Speed.	
	Km.	Miles.				Km./h.	Miles/h.
Milan P. N.-Novara	49	30	0.56	6	Accelerated A.	52.3	32.5
Piacenza-Voghera	58	36	1.11	9	Do.	49.0	30.4
Aosta-Chivasso	100	62	2.21	23	Do.	42.5	26.4
Milan-Condogno	60	37	1 06	8	Do.	54.5	33.9
Florence-Arezzo	87	54	1.45	14	Do.	49.7	30.8
Bolzano-Verona	147	91	3 00	26	Do.	49.0	30.4
Bologna-Ferrara	47	29	0.54	6	Do.	52.2	32.4
Barletta-Bari	55	34	1.02	6	Do.	53.4	33.1
Milan C.-Piacenza	72	45	1.50	10	Accelerated.	39.3	24.4
			1 25	11	A. train.	50.8	31.6
			1.19	*3*	*Diretto.*	*54.7*	*34.0*
			0.55	*0*	*Direttissimo*	*78.6*	*48.8*
Florence-Arezzo	88	55	*1.58*	*14*	*Local.*	*44.7*	*27.7*
			2.09	14	Accelerated.	40.9	25.4
			1.47	14	A. train.	49.3	30.6
			1 35	*1*	*Diretto.*	*55.5*	*34.5*
			1.28	*0*	*Direttissimo.*	*60.0*	*37.3*
Metaponto-Sibari	80	50	*2.13*	*10*	*Misto.*	*36.0*	*22.4*
			2.15	10	Accelerated.	35.6	22 0

junction with refrigerator wagons and containers ([1]). As England is one of Italy's chief customers, care has been taken to build these units to dimensions suitable for running in England after crossing by the Zeebrugge-Harwich ferry-boats.

This stock is used for « derrati » (perishable goods) regular or special trains each made up of 8 to 10 of these special wagons, which are well lighted so that the contents can be dealt with and sorted out en route. These trains link up the large producing to the large consuming centres, and serve the entire length of the peninsula.

The rakes from various places join at appropriate stations, and on arrival, are divided up again in the same way.

Thus, from the Cancello marshalling yards, where rakes from Sicily, Calabria and the Campania arrive, the « derrati ordinari » trains convey, to the frontier, goods covered by the export certificate of the National Office.

Another train of this class (letter I) serves Apulia, the Marches, and the Romagna.

([4]) So that they can be easily handled, these containers have the following dimensions : 2.15 m. × 2.60 m. × 2 m. to 2.50 m. (7 ft. 5/8 in. × 8 ft. 6 3/8 in. × 6 ft. 3/4 in. to 8 ft. 2 7/16 in.). They are loaded in threes on flat wagons. The double isothermic steel walls have insulating material between them, and are fitted with 2 ice tanks, each holding 150 kgr. (330 lb.) of ice.

Fig. 170. — « Derrati » (perishable-goods) train routes.

The trains from Catania are ferried across the Straights from Messina to Reggio di Calabria, whence they run on to Naples, Bologna, and Brennero (frontier).

The special « derrati » trains, worked during the fruit season, run at higher average speeds than do the others.

TABLE 168.

THROUGH PERISHABLE-GOODS TRAINS (fig. 170).

Train.	RUN.	Distance		Time of departure.	Time spent.	Speed	
		Km.	Miles.			Km./h.	Miles/h.
	Ordinary trains.						
GG	Cancello-Chiasso	926	575	8.20 p. m.	31.23	29.1	18.1
DD	Do. -Brennero	1020	634	9.05 p. m.	33.15	30.6	19.0
PP	Do. -Tarvisio	1090	652	7.35 p. m.	38.05	27.6	17.2
	Bari-Brennero	1001	622	5.50 p. m.	41.50	24.0	14.9
	Special « Derrati » trains.						
RRC	Cancello-Chiasso	892	554	1.18 a. m.	25.02	35.7	22.1
RRM	Do. -Brennero	1020	634	6 10 p. m.	28 15	36.0	22.4
RRP	Bari-Tarvisio	1023	636	8 20 p. m	30.14	34.1	21.2
RRS	Rimini-Chiasso	382	237	6.35 p. m.	11.15	34.0	21.1
	Other « Derrati » trains.						
FF	Lecce-Bologna-Brennero	1150	715	8.17 a. m.	51.03	22.5	14.0
GGS	Milan-Domodossola	125	78	12.05 a. m.	4.36	23.8	14.8
MM	(Rimini) Piacenza-Modane	294	182	9.05 p. m.	9 55	29.6	18 4
MM	Palermo Cent.-Messina	233	145	11.15 p. m.	7.38	30 5	18.9
NN	Siracusa-Messina	185	115	9.05 p. m.	6.58	26.4	16.4
	Accelerated and through goods trains.						
	Milan-Ancona	423	265	5.40 a. m.	11.58	35.3	21.9
	Do. -Foggia	736	458	R7.30 p. m.	26.00	28.3	17 6
	Do. -Genoa	149	93	7.37 p. m.	6 23	23.3	14.5
	Do. -Venice	267	166	12.45 a. m.	7.45	34.0	21.1
	Do. -Bologna	219	136	5.40 a. m.	7 15	30.2	18.9
	Genoa-Rome	401	248	7.15 a. m.	16 15	24.6	15 3
	Bologna-Rome	413	256	11.55 a. m.	11.25	36.1	22.4

XXX-4. — **The Sleeping-Car Company** (fig. 171). — Together with Austria, Italy was one of the first European countries to boast sleeping cars. The former came to an agreement with the *Mann Boudoir Sleeping-Car Company,* whilst its American competitor, the *Pullman Palace Car Company* introduced, in 1875, a sleeping-car service between the French frontier (Modane) and Florence, with a projected extension to Brindisi.

The services maintained by both these American Companies were taken over by the *International Sleeping-Car* Co. which bought the 9 Pullman sleeping cars then working in Italy.

Figure 172 shows one of the first bo-

Légende

Ä	Ägypten Express
BRN	Berlin Roma Napoli
BTR	Berlin Tyrol Roma
G	Gothard Express
Ll	Lloyd Express
NSBr	Nord Sud Brenner (Merano)
OWT	Ostende Wien Trieste (Fiume)
PO	Peninsular & Oriental
PR	Paris Roma Napoli (Firenze)
R	Riviera Express (Rome)
RFC	Roma Firenze Cannes
S	Simplon - Orient
SP·WNC	St.Pét. - Wien Nice Cannes
WL	Train de Wagons - lits
WRN	Wien Roma Napoli
WTR	Wien (Budapest) Tyrol Roma
P	Trains Pulman

Fig. 171. — Map of Italian lines run over by *International Sleeping-Car Company* trains.

Fig. 172. — Old Italian sleeping car, built by the Savigliano Works, in 1884.

gie sleeping cars with open vestibules, built in Italy by the *Savigliano Works*.

Besides isolated services, the Sleeping-Car Co. introduced a whole series of « de luxe » trains, which we have grouped as follows :

a) Boat trains;
b) Transit trains;
c) National or internal trains.

a) Boat trains run by the Sleeping-Car Co. — In Western Europe, a great many short-distance boat trains are run in connection with the Channel services. In Italy, on the other hand, there are a number of long-distance international trains giving fast connections with the Me-diterranean steamers, in particular, those sailing for Egypt or India. This is due to Europe's geographical features owing to which it is possible to catch, at an intermediate port of call, the boats which have previously left our Northern ports.

Thus the Anglo-Indian *P. and O.* liners called at Marseilles and Brindisi, and could be caught by means of connecting trains leaving London 5 or 7 days later than the boat. The *Sleeping-Car Co.* therefore ran « de luxe » trains from Calais to each of these ports.

The « Bombay Express », between Calais and Marseilles, connected at Calais with a train from London which left the Wednesday after the boat sailed [1].

---

[1] This train left Calais at 3.0 p. m. and arrived at Paris *P.L.M.*, after running through Paris *Nord*, at 7.57 p. m. It left for Marseilles-Joliette (Arenc) an hour later.

TABLE 169.

ITALIAN SERVICES OF INTERNATIONAL SLEEPING-CAR COMPANY TRAINS (fig. 171).

ORIGIN. (Outside Italy.)	ITALIAN SECTION OF THE RUN — Frontier	via	Frontier	Destination. (Outside Italy.)	Distance. Km.	Miles.	Time of departure.	Time spent.	NAME OF TRAIN.
	Transit services.								**Before 1914.**
Cannes	Ventimiglia-Verona-S. Candido			Vienna and Budapest.	709	441	12.52 a. m.	18.18	Vienna-Tyrol-Cannes Exp. (1913).
Cannes	Ventimiglia-Milan-Brennero			Berlin.	680	423	12.25 a. m.	17.37	Nord-Sud Brenner Exp.
									Since 1918.
Cannes	Ventimiglia-Milan-Chiasso			Berlin.	351	208	4.30 p. m.	7.20	Riviera Express.
Cannes	Ventimiglia-Venice-Tarvisio			Vienna.	795	494	1.35 p. m.	15.55	(St. Petersburg)
Calais, Paris	Domodossola	Milan-Trieste	Postumia.	Bucharest.	559	347	7.35 a. m.	12.10	Vienna-Nice-Cannes Express.
Ostend	Chiasso	Milan-Trieste	Longatico.		928	577	1.02 p. m.	13.20	Simplon-Orient Express.
Lyons	Modane	Milan-Trieste	Do.		710	441	7.30 a. m.	19.52	Do.
	Services between Italy and abroad.								**Before 1914.**
Cannes	Ventimiglia-Pisa	Rome		...	552	343	7.45 p. m.	17.45	Rome-Florence-Cannes.
		Florence			397	246	Do.	11.30	Do.
Calais-Pierrefitte	Modane-Bologna-Brindisi			...	1239	770	6.05 p. m.	23.40	Peninsular Express.
Paris P.L.M.	Modane-Rome	Palermo		...	1718	1067	1.20 a. m.	38.45	Paris-Rome-Naples.
		Taormina			1534	953	Do.	34.22	Palermo-Taormina.
Altona, Berlin.	Chiasso-Milan-Genoa			...	200	124	11.47 a. m.	4.23	Lloyd Express.
Berlin.	Brennero-Bologna-Rome			...	800	497	5.21 a. m.	16.49	Berlin-Tyrol-Rome Exp.
Berlin.	Brennero-Merano			...	122	76	12.29 p. m.	3.16	Nord-Sud-Brenner Exp.
Berlin.	Brennero-Rome-Naples			...	1049	652	12.30 p. m.	22.35	Ägypten Express.
Berlin.	Brennero-Rome	Palermo		...	1999	1242	12.06 a. m.	42.04	Berlin-Rome-Naples-Palermo Exp.
		Giard. Taormina			1566	972	...	...	Do.
Vienna-Semmering	Tarvisio-Rome	Palermo		...	1789	1112	1.35 a. m.	34.32	Vienna-Rome-Naples-Palermo Exp.
		Giard. Taormina			1605	997	Do.	38.52	Do.
Ostend-Vienna	Postumia-S. Pietro	Trieste		...	82	51	5.41 a. m.	1.29	Ostend-Vienna-Trieste.
		Fiume			60	37	...	...	Do.
									Since 1918.
Berlin.	Chiasso-Milan-Florence-Rome			...	683	424	5.10 a. m.	10.20	Riviera Express.
Cannes	Ventimiglia-San Remo-Milan			...	305	189	R 9.00 a. m.	5.45	Milan-S. Remo-Nice-Cannes Pull.
Calais.	Domodossola-Milan-Florence			...	441	274	7.55 a. m.	7.39	Simplon-Orient Express (1935).
Paris P.L.M.	Modane-Pisa	Rome		...	772	479	8.00 a. m.	11.50	Paris-Rome Express.
		Florence			527	327	Do.	8.47	Do.
Do.	Modane-Pisa-Rome	Palermo		...	1833	1140	...	...	Do.
		Siracusa			1785	1109	...	...	Do.
Do.	Modane-Rome-Bari-Taranto			...	1386	861	4.10 a. m.	31.59	In 1919 and 1920.
Do.	Modane-Rome-Caserte-Brindisi			...	1380	858	2.45 a. m.	32.31	In 1921
Paris E. and Zurich	Chiasso-Milan			...	51	32	7.50 p. m.	0.55	Gothard Pullman Express.
	Home services.								**Since 1918.**
	Rome-Genoa-Turin			...	667	414	9.20 p. m.	11.00	All-sleeping-car train.
	Rome-Fornovo-Milan			...	621	386	10.00 p. m.	10.20	Do.
	Rome-Bologna-Venice			...	609	378	8.00 p. m.	12.23	Do. (1926).
	Rome	Reggio di Cal.		...	688	427	8.15 p. m.	14.45	Do.
	Messina	Palermo		...	915	566	8.15 p. m.	19.45	Do.
		Siracusa		...	865	537	Do.	18.56	Do.
	Rome-Naples			...	214	133	11.30 a. m.	2.40	Pullman Express (1929).

Long ago the English Post Office organised, from Calais to Brindisi, a train known as the « Indian Mail » which even ran via Ostend and Basle during the Franco-Prussian war. The *Sleeping-Car Co.* substituted the « P. and O. Ltd. Express » to it; this was, a « de luxe » mail train with accomodation for 60 passengers. It left Calais on the Friday and returned by one of nine schedules according to the time of the liner's berthing at Marseilles ([1]).

Two competitors for Egyptian traffic arose : an Austrian line via Trieste, and a German one via Naples.

The « Ostend-Vienna-Trieste Express » first ran on the 1st December 1896, and brought London within 5 3/4 days travel from Alexandria, by *Austrian Lloyd* steamers ([2]). A rake for Fiume, which was detached at St. Peter (San Pietro), only had a very brief existence.

Later on, « de luxe » trains were run between Berlin and the Italian ports at which German boats called.

TABLE 170.
ITALIAN BOAT TRAINS.

ipping npany.	RUN.	Harbour.	Distance		Time of departure.	Time spent.	Speed.		
			Km.	Miles.			Km./h.	Miles/h.	
	Sleeping Car. Co. trains.								
& O.	(Calais) Modane-Bologna-Ancona-	Brindisi Mar. .	239	148.5	6.10 p. m.	*23.40*	*52.4*	*32.6*	*P. and O. Express.*
	(Vienna) St. Pietro-	Trieste Mar. .	69	42.9	5.43 a. m.	*1.27*	*47.6*	*29.6*	*Ostend-Vienna-Trieste.*
er. Ll.	(Calais) Modane-Rome-	Naples Mar. .	1 022	635.0	1.40 a. m.	*22.55*	*44.4*	*27.6*	*Paris-Rome Exp.*
Gle. It.	(Berlin) Brennero-Rome	Naples Mar. .	1 050	652.5	12.49 p. m.	*21.51*	*48.1*	*29.9*	*Ägypten Express.*
H. A.	(Berlin) Chiasso-Milan-	Genoa . . .	200	124.3	11.47 a. m.	*4.23*	*45.6*	*28.3*	*Lloyd Express.*
D. Ll.	(Paris) Modane-Rome-	Taranto Mar. .	1 458	906.0	4.10 a. m.	*21.59*	*39.7*	*24.7*	*Paris-Rome-Taranto.*
	(Paris) Modane-Rome-	Brindisi Mar. .	1 454	903.5	2.45 a. m.	*22 31*	*32 2*	*20.0*	*Paris-Rome-Brindisi.*
	Italian State Ry. trains.								
	Rome Central-Naples-	Brindisi Mar. .	546	339.3	8.15 p. m.	*15.05*	*36.3*	*22.6*	*Rapido.*
	Milan-Bologna-Ancona-	Brindisi Mar. .	980	608.9	R 1.35 p. m.	*18.57*	*51 6*	*32.1*	*Do.*
	Milan-Rome Tib.-	Naples Mar. .	853	530.0	12.30 a. m.	*11.40*	*73.1*	*45.4*	*Do.*

([1]) The train left Calais at 1.0 a. m. and joined the *P.L.M.* system via Pierrefitte-Villeneuve Yard. At Pierrefitte, it picked up a Paris connection and reached Brindisi at 5.20 p. m. on the Sunday.

([2]) Departure from London for Brussels at 9.0 a. m. via Calais, and at 10.0 a. m. via Ostend. The rake from Calais took 4 hours to reach Brussels, that from Ostend 1 hour 44 minutes. The train arrived at Vienna West and only left from Vienna South 6 1/2 hours later.

By leaving London on Monday morning, Trieste was reached on Wednesday morning at 10.58 a. m. and Alexandria at dawn, the following Sunday morning.

The « Ägypten Express » and the « Lloyd Express » were *Hamburg-Amerika* and *Norddeutscher Lloyd* trains run from Berlin, respectively to Naples via the Brenner Pass (*Hamburg-Amerika*)(1), and to Genoa via the St. Gothard (*Norddeutscher Lloyd*) (2).

Finally the « Paris-Rome-Naples Express » connected in Naples with the *Sta. Gle. Italiane de Navigazione's* boats for Alexandria, which could thus be reached from London in 4 days 21 hours (3).

The « P. and O. Express » from Calais to Marseilles is the only one of these trains which has survived since the war (4).

On the other hand, two « de luxe » trains introduced in 1902, gave a rather unexpected connection between France and her North-African Colonies via Italy. On the European side, the « Paris-Rome-Naples Express » was extended twice a month as far as Palermo so as to connect with Italian mail boats. These further connected in Africa with the « Tunis-Constantine-Algiers-Oran Express », a « de luxe » train which, in spite of some ten hours spent at Algiers, gave through connection with the outlying parts of Morocco (5).

After the armistice, so as to avoid running through the still unsettled States issued from the former Austro-Hungarian Empire, the « Paris-Rome Express » was again called upon to cover the services between the Western Capitals and the Near East. It was first extended from Rome to Taranto (6), and later from Rome to Bari and Brindisi (7) whence passengers proceeded by boat to Greece and Turkey. However, as soon as political considerations made it feasable, the « Paris-Rome Express » returned to its normal route through Naples to Sicily, and the « Peninsular Express » from Brindisi was abandoned.

THE SLEEPING-CAR Co.'s TRANSIT TRAINS include a West and East train, the « Simplon-Orient Express » and a series of « de luxe » trains from the Riviera to the North and North-East.

The first of them is of primary importance to Italy. Before the war, the « Simplon Express » only ran as far as Milan, then on to Venice; although a Mestre-Venice rake was maintained, it was afterwards extended from Mestre to Trieste and the former « Ostend-Trieste-Express » (through Vienna) done away with, the journey from London being considerably shorter via the Simplon than through Vienna.

But this train's prominence is a postwar one, for it was possible, by its means and without running through the former Austro-Hungarian Empire, to link up the Western Capitals with the

---

(1) This train left Berlin on the Wednesday at 10.32 p. m. and arrived at Naples on the Saturday at 10.40 a. m.. Alexandria was reached on the Wednesday at midday.

(2) The train left Berlin at 3.05 p. m. and arrived at Genoa the next day at 4.10 p. m. It carried a rake from Berlin to Basle and Coire, detached from the « Riviera Express », which ran into France via Mulhouse.

(3) It left London on the Thursday at 9.0 a. m. and arrived at Naples on the Saturday at 7.0 a. m.. Departure at 3.0 p. m. and arrival at Alexandria on Tuesday at dawn.

(4) This train now runs from Calais to Paris P.L.M. via La Chapelle Charbon. It takes 18 h. 37 m. from Calais to Marseilles.

(5) Departure from Paris P.L.M. at 1.35 p. m. so as to arrive at Palermo the second day at 7.30 p. m. The African « de luxe » train left Tunis at 6.55 a. m. and arrived at Constantine at 8.49 p. m., Algiers the next day at 10.50 a. m., and Oran the day after at 6.34 a. m.

(6) During 1919 and 1920, it left Paris at 2.0 p. m. It did not serve Naples.

(7) In 1921, this train left Paris at 11.40 a. m. Beyond Rome, it ran via Caserte, where Naples rake was detached.

Near Est, far better than by the temporary « Paris-Rome-Naples-Brindisi » extension.

Three rakes were run respectively from Lyons (Bordeaux), via the Mount Cenis, from Ostend (via the Saint-Gothard) and from Paris (via the Simplon), and joined up in Milan whence they continued together as far as Bucharest (¹). Owing to various causes, the rakes from Ostend and Lyons have been suppressed, the Paris one alone still running, and the Eastern services, have been considerably extended.

Early in 1935, a further branch was added. A rake from Paris was run off in Milan and, by means of the new « diretissima », proceeded through Bologna to Florence.

By this route, the distance from Paris P.L.M. to Florence works out at 1 139 km. (708 miles) as against the 1 338 km. (831 miles) (²) by the « Paris-Rome »'s Pisa-Florence rake. The time taken is 18 h. 54 m. for the former, and 18 h. 50 m. for the latter.

Several of the Riviera trains entered Italy from the East, either through the St. Gothard, the Brenner, San Candido or Tarvisio. They were :

The « Rome-Florence-Nices-Cannes Express »;
The « Vienna-Tyrol-Cannes Express », with a rake from Budapest;
The « St. Petersburg-Vienna-Nice-Cannes Express ».

The latter only, with the St. Petersburg-Vienna section severed, still runs,

together with a new Berlin « Riviera Express ».

The first « Riviera Express », duplicating the « Mediterranean Express » between Marseilles and Mentone had first run in 1898. Extended long before the war from Marseilles to Lyons, Mulhouse and Berlin, it now again runs up to Berlin but reaches the Riviera from the East instead of the West, proceding through the St. Gothard and Milan. It carries a rake for Florence and Rome, running, as does the new branch of the « Simplon Express », over the new Bologna and Florence « direttissima ».

TRAINS FROM ITALY TO ABROAD link up the capitals of Western and Central Europe — (London) Paris, Berlin, Vienna, and formerly Budapest — with Rome (and Florence).

The first of these trains is a very old one. It was an extension to Rome of the « Calais-Paris-Nice ». The traffic soon justified the introduction of a special Paris and Rome train, which ran through Mount Cenis and thus shortened the journey by 329 km. (204.4 miles) (³).

The different trains were soon extended to Sicily by means of the S. Giovanni-Messina ferryboat, whence they ran alternatively to Palermo or Taormina (and later to Syracusa).

There are two categories of INTERNAL TRAINS : night trains made up exclusively of sleeping cars, and day Pullman expresses.

---

(1) The timetable was then :
Paris 7.30 p.m., Domodossola (Central European time) midday, Milan 2.25 p.m.
Lyons 9.51 p.m., Modane (Central European time) 7.30 a.m., Milan 2.0 p.m.
Ostend 2.30 p.m., Chiasso (Central European time) 1.02 p.m., Milan 2.15 p.m.
Departure from Milan at 2.55 p.m., Trieste 12-12.30 a.m., Longatice 2.22-3.50 a.m.
At the present time the « Simplon-Orient Express » runs from Trieste via Postumia.
(2) Both trains run along the same route, from Paris to Dijon, a distance of 315 km. (196 miles).
(3) The distance from Paris to Rome is 1 123 + 652 km. (697.8 + 405.1 miles) via Ventimiglia, and 673 + 773 km. (418.2 + 480.3 miles) via Modane.

All-sleeping-car trains were originally started in Italy, and run according to traffic requirements and possibilities. They link up Rome with the large provincial cities : Turin, Milan, Venice in the North, Reggio di Calabria, Palermo and Syracusa in the south.

Although some all-sleeping-car trains have been run in other countries ([1]) only the Italian trains remain.

As for the Pullman express trains, three of these have been withdrawn owing to traffic curtailment, and only the « Milan-San Remo-Nice-Cannes Express » still runs.

SPEED OF THE SLEEPING-CAR CO.'S TRAINS. — Recently, the *State* Railway's expresses have been speeded up, but this acceleration has not been extended to the « de luxe » trains, whose running times are slower than those of the « rapidi » over the same routes.

The timings of the all-sleeping-car trains is purposely kept rather low so that passengers can enjoy a peaceful night's rest.

TABLE 171.

COMPARATIVE TIMINGS OF SLEEPING-CAR COMPANY TRAINS AND (*in italics*) FAST TRAINS OF THE ITALIAN STATE RAILWAYS.

RUN.	Distance		Time of departure.	Time spent.	Speed		
	Km.	Miles.			Km./h.	Miles/h.	
Compared timings.							
Milan-Venice	267	165.9	10 20 a. m.	4.03	65.9	40.9	Simplon-Orient Exp.
			11.57 a. m.	*2.58*	*90.0*	*55.9*	*Rapido.*
Milan-Genoa	154	95.7	9.00 a. m.	2.20	66.0	41.0	Riviera Express.
			12.10 p. m.	*1.57*	*79.0*	*49.1*	*Rapido.*
Trieste Cent.-Venice S. L. . .	146	90.7	11.45 a. m.	2 48	52.2	32.4	Simplon-Orient Exp.
			9.40 a. m.	*2.10*	*67.4*	*41.9*	*Rapido.*
All-sleeping-car trains.							
Rome-Genoa-Turin	667	414 5	9.20 p. m.	11 00	60 6	37.7	All-sleeping-car train.
Turin-Alessandria	91	56.5	9 10 p. m.	1.10	78.0	48.5	Do.
La Spezia-Pisa	75	46.6	R 2.49 a. m.	1.02	72.6	45.1	Do.
Rome-Fornovo-Milan	621	385.9	R 10.20 p. m.	10.15	60 6	37.7	All-sleeping-car train.
Fornovo-Viareggio . . .	151	93.8	12.19 a. m.	2 13	68.1	42.3	Do.
Rome-Siracusa	865	537.5	8.15 p. m.	18.56	45.6	28.3	All-sleeping-car train.
Naples-Salerno	54	33.6	11.39 p. m.	1.11	45.6	28.3	Do.
Salerno-Paola	220	136.7	12 56 a. m.	5.34	40 0	24 9	Do.
San-Eufemia-Reggio di Cal.	128	79.5	R 11.05 p. m.	2.47	46.3	28.8	Do.

[1] These *Sleeping-Car Company* trains were :

Warsaw-Poznan ;   Paris-Nice ;

Paris-Switzerland-Vienna, which has since become the « Arlberg-Orient Express ».

The *Mitropa* has introduced a similar train between Holland, Berlin, and Switzerland.

TABLE 172.

LEADING DIMENSIONS OF RAIL MOTOR COACHES.
(Figs. 174 and 175.)

VEHICLE.	State.	State. S. F. B.	State.	State.	State.
Builder	Fiat.	Fiat.	Fiat.	Fiat.	Breda.
Track gauge	1.435 m. (4′ 8 1/2″)	1.435 m. (4′ 8 1/2″)	1.435 m. (4′ 8 1/2″)	1.435 m. (4′ 8 1/2″)	1.435 m. (4′ 8 1/2″)
Body, length	7.400 m. (24′ 3 11/32″)	14.800 m. (48′ 6 5/16″)	17.600 m. (57′ 9″)	22.000 m. (72′ 2″)	16.000 m. (52′ 6″)
Exterior height	3.000 m. (9′ 10 1/8″)	3.040 m. (9′ 11 3/4″)	3.000 m. (9′ 10 1/8″)	3.140 m. (10′ 3 5/8″)	3.100 m. (10′ 2″)
Body, width	2.350 m. (7′ 8 1/2″)	2.400 m. (7′ 10 15/32″)	2.400 m. (7′ 10 15/32″)	2.600 m. (8′ 6 1/2″)	2.850 m. (9′ 4 1/4″)
Wheels	4	8	8	8	8
Bogie wheel base	3.000 m. (9′ 10 1/8″)	2.800 m. (9′ 2 5/16″)	2.800 m. (9′ 2 5/16″)	3.000 m. (9′ 10 1/8″)	2.700 m. (8′ 10 5/16″)
Distance between bogie centres	. . . .	9.550 m. (31′ 4″)	12.350 m. (40′ 6 1/4″)	16.500 m. (54′ 2″)	10.390 m. (37′ 4 7/16″)
Wheel diameter	0.720 m. (2′ 4 3/8″)	0.910 m. (2′ 11 7/8″)	0.910 m. (2′ 11 7/8″)	0.910 m. (2′ 11 7/8″)	0.700 m. (2′ 3 1/2″)
Weight, empty	6.0 t. (5.9 Engl. t.)	12.5 t. (12.3 Engl. t.)	13.5 t. (13.3 Engl. t.)	20.0 t. (19.7 Engl. t.)	12.5 t. (12.3 Engl. t.)
Weight, fully loaded . . .	9.0 t. (8.85 Engl. t.)	17.0 t. (16.7 Engl. t.)	20.0 t. (19.7 Engl. t.)	28.0 t. (27.55 Engl. t.)	. . .
Number of passengers carried	24	48	64	80	38 + 20
Dead weight per passenger.	250 kgr. (551 lb.)	260 kgr. (573 lb.)	210 kgr. (463 lb.)	250 kgr. (551 lb.)	215 kgr. (474 lb.)
Maximum hourly speed. .	50-75 km. (31-46.6 miles)	115 km. (71.5 miles)	105 km. (65.3 miles)	130 km. (80.8 miles)	120 km. (74.6 miles)

The *Sleeping-Car Co.*'s trains and some of the international expresses are designated by letter and not by number [1]. The *Sleeping Car Co.* now operates 16 sleeping-car all-Italian services, 14 of which start from Rome [2]. To these must be added 2 transit services, and 24 international services, 8 of which start from Rome.

---

[1] For example :

MB — Milan-Bordeaux (rapide).
SO — Simplon-Orient Express.
VN — Vienna-Nice-Cannes Express.

PR — Paris-Rome Express.
MN — Milan-Nice-Cannes Pullman Express.
BR — Berlin-Riviera Express.

[2] The interprovincial services are those from Genoa to Milan and Venice, and from Milan to Verona and San Candido.

Fig. 173. — Italian railcar routes.

CHAPTER XXXI.

Italian train speeds.

XXX-1. — **General.** — Considerable efforts have been made, within recent years, to increase the speed of all classes of trains. We have called attention to the introduction of fast expresses (« rapidi ») and perishable goods (« derrati ») trains. Below, we give tables showing the noteworthy runs, and the usual information about the fastest trains and the longest non-stop runs (see also·fig. 176), steam traction, electric traction and rail motor cars being shown separately.

XXXI-2. — **Rail motor coach services** have been specially developed in the Foggia-Bari, Naples, and Leghorn districts (fig. 173).

The vehicles are usually high-speed units, sometimes used in A train services (light accelerated trains).

Of the sections run over by the Biella-Alessandria service, the first — Biella to Santhia — belongs to an independent secondary company.

Fast triplet articulated sets of Diesel cars are about to be ordered for running Turin-Venice expresses (414 km. = 258 miles) in 3 1/2 hours, at an inclusive speed of some 75 miles per hour.

These sets are 59.61 m. (194 feet) long
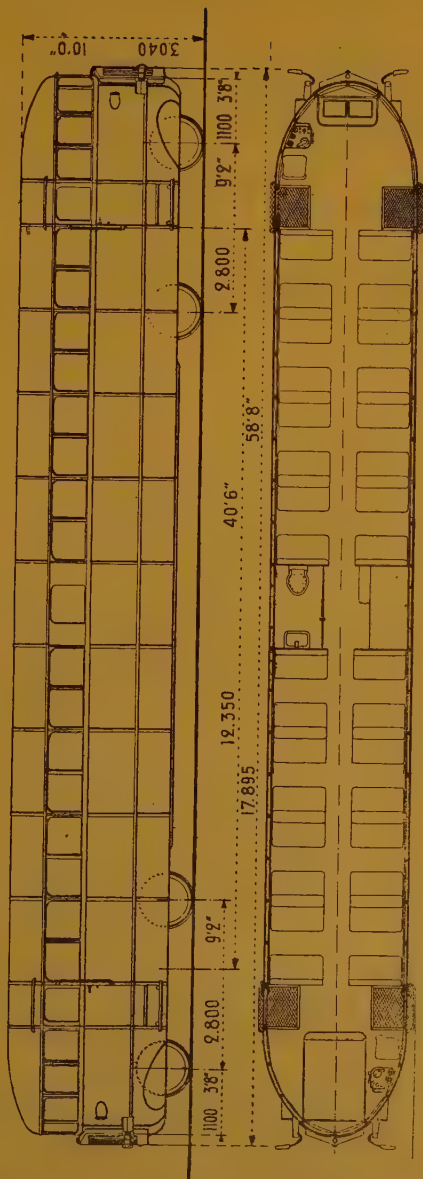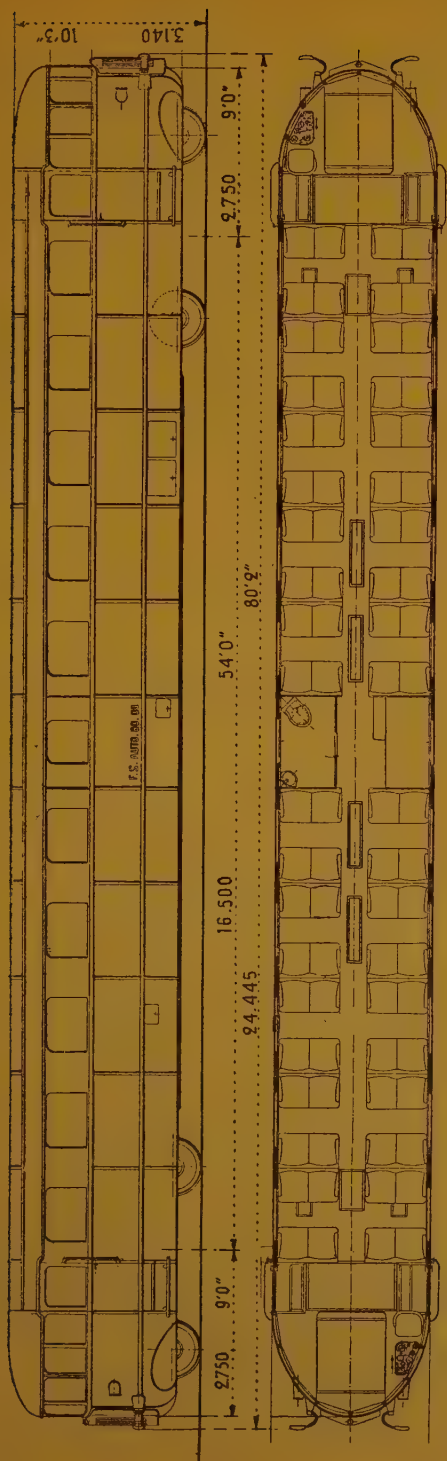
Fig. 174. — 80 and 64-seater Fiat railcars,

TABLE 173.

ITALIAN RAIL MOTOR CAR SERVICES (fig. 173).

RUN.	Distance		Time of departure.	Time spent.	Speed		Number of stops.	
	Km.	Miles.			Km./h.	Miles/h.		
Turin-Chavisso-Aosta	129	80.2	R 10.35 a. m.	2.03	60.5	37.6	6	
Chivasso-Ivrea	33	20.5	R 11.42 a. m.	0.29	68.3	42.4		
Turin P. S.-Chiasso	23	14.3	R 12.14 p. m.	0.17	81.2	50.5		
Biella-Santhia-Casale-Alessandria.	105	65.3	6.20 a. m.	1.51	66.8	41.5	8	
Biella-Santhia	30	18.6	Do.	0.25	72.0	44.7	3	Company.
Casale M.-Valenza	19	11.8	7.41 a. m.	0.16	71.2	44.2		
Leghorn-Pisa-Florence S. M. N. .	101	62.8	7.35 a. m.	1.25	71.3	44.3	3	
Leghorn-Pisa	20	12.4	Do.	0.17	70.6	43.9		
Pisa-Empoli-Florence . . .	81	50.3	R 3.15 p. m.	1.15	64.8	40.3		Direttissimo.
Pisa-Pontedera	20	12.4	7.53 a. m.	0.15	80.0	49.7		
Pontedera-Empoli	27	16.8	8.09 a. m.	0.20	81.0	50 3		
Empoli-Florence	34	21.1	8.30 a. m.	0 30	68.0	42.3		
Siena-Empoli (Florence) . . .	64	39.8	7.15 a. m.	0.57	67.4	41.9	3	
Siena-Poggibonsi	26	16.2	Do.	0.21	74.3	46.2		
Naples Cent.-Castellamare . . .	28	17.4	10.25 a. m.	0.26	64.6	40.1		
Naples Cent.-Torre Annunziata.	22	13.7	Do.	0.15	88.0	54.7		
(S. Severo) Foggia-Bari . . .	123	76.4	8.40 a. m.	1.31	81.1	50.4	2	
Foggia-Cerignola Camp. . .	35	21.7	Do.	0.24	87.5	54.4		
Cerignola-Barletta	33	20.5	9.04 a. m.	0.27	73.3	45.5		
Barletta-Bari C.	55	34.2	9.31 a. m.	0.40	75.5	46.9		
Foggia-Barletta	68	42.3	R 4.29 p. m.	0.51	80.0	49.7		
Barletta-Spinazzola	66	41 0	3.30 p. m.	1.08	58.2	36.2	2	
Barletta-Canosa	25	15.5	Do.	0.22	68.2	42.4		
Canosa-Minervino	19	11 8	3.53 p. m.	0.22	51.8	32.2		
Minervino-Spinazzola . . .	22	13.7	4.16 p. m.	0.22	60.0	37.3		
Bari Cent.-Lecce	149	92.6	6.40 p. m.	1.52	79.8	49.6	1	
Bari-Brindisi	111	69.0	Do.	1.20	83.3	51.8		
Brindisi-Lecce	38	23.6	8.14 p. m.	0.30	76.0	47.2		
Bari-Taranto	115	71.5	8.39 a. m.	1.32	75.0	46.6	2	
Bari-Gioia del Colle . . .	54	33.6	Do.	0.44	73.8	45.9		
Castellaneta-Taranto	40	24.9	9.42 a. m.	0.30	80.0	49.7		
Foggia-Potenza	119	73.9	5.25 a. m.	2.55	40.3	25.0	17	
Foggia-Lucera	21	13.0	8.05 a. m.	0.18	70.0	43.5		
Foggia-Manfredonia-Citta . . .	37	23.0	11.45 a. m.	0.33	67.3	41.8	1	
Foggia-Manfredonia	36	22.4	Do.	0.30	72.0	44.7		

over buffers (1), and are expected to weigh 75 tons, for a seating capacity of

(1) Length, buffers excluded, 59 m. (193 ft. 6 in.).
The two middle bogies have 3.500 m. (11 ft. 5 3/4 in.) wheel base each, the outer bogies, each with a 400-B.H.P. engine, 4.500 m. (13′ 3″ 1/2) and 3.150 m. (10 ft. 4 in.) respectively.
Between bogie centres : intermediate unit, 17.550 m. (57 ft. 7 in.), outer units, 17.320 m. (56 ft. 9 7/8 in.); distance to outer end of the sets, buffers excluded, 3.400 m. (11 ft. 1 7/8 in.).
These units have a smaller cross section than the electric vehicles; their width is 2.700 m. (8 ft. 10 1/4 in.) as against 2.920 m. (9 ft. 7 in.) in the case of the electric coaches.

36 first-class in the centre unit, and 42 second-class in the rear one, the leading unit having, besides the driver's compartment and van, a kitchen and other appliances for serving meals en route.

XXXI-3. — **Electric services**. — Owing to its natural wealth in water power, Italy is gradually electrifying a considerable part of its railway system; at the present time, 2 224 km. (1 382 miles) (13.70 %) of main lines ([1]) and over 1 915 km. (1 190 miles) of private and secondary lines have been electrified, to which should be added 1 764 km. (1 096 miles) of main lines soon to be electrified.

Electric traction was first tried in 1899 between Milan and Monza (12 km. = 7.5 miles), a motor coach being used. Electrification of the Varese line was completed in 1901.

Heavy traffic on the relatively easy Ventimiglia-Leghorn line justified its electrification, which it is proposed to extend right down to Reggio di Calabria,

TABLE 174.

ITALIAN ELECTRIC SERVICES.

RUN.	Distance		Time of departure.	Time spent.	Speed.		
	Km.	Miles.			Km.|h.	Miles/h.	
Modane-Genoa-La Spezia-Pisa . .	362	225	8.00 a. m.	6.06	59.4	36.9	Paris-Rome Express.
Modane-Turin	106	65.8	Do.	2.00	54.0	33.6	Do.
Turin-Asti	56	35	10.10 a. m.	0 42	80 0	49.7	Do.
Genoa-La Spezia	87	54	12.02 a. m.	1.21	72.6	45 0	All-sleeping-car train.
La Spezia-Pisa	75	41	R 2.49 a. m.	1.02	72.6	45.1	
(Milan) Bologna-Florence . . .	97	61	9.37 a. m.	1 06	90 9	56.5	Rapido.
Milan P. N.-Varese	59	37	9.01 a. m.	0.41	86.3	53.6	
Milan (Gallarate)-Legnano .	29	18	6.04 a. m.	0 21	82.9	51.6	
Milan C.-Gallarate	44	27	9.00 a. m.	0.45	59.8	37.2	
(Milan) Monza-Varenna-Sondrio .	118	73	R 9.30 a. m.	2.18	51.3	33 6	6 stops.
Monza-Lecco	38	24	R 11.12 a. m.	0.36	63.3	39.3	
Lecco-Varenna	21	13	10.11 a. m.	0.27	46.8	29.1	
Colico-Chiavenna	27	17	R 12.45 p. m.	0 33	49.8	30.9	
Brennero-Bolzano-Gries . . .	90	56	10.52 p. m.	1.44	51.9	32.3	3 stops.
Bressanone-Bolzano-Gries . .	38	24	11 54 p. m.	0.44	51.8	32.3	
Rome-Sulmona (Pescara) . . .	172	107	11.22 p. m.	3 12	53.7	33.3	7 stops.
Avezzano-Sulmona	64	40	1.40 a. m.	1.04	60.0	37.3	
Naples-Villa Literno	30	19	10.08 a. m.	0.23	78.3	48.7	
MIXED TRACTION.							
Milan-Voghera-Genoa	149	93	12.10 p. m.	1.57	76 4	47.5	Rapido.
Rome-Villa Literno-Naples Mer. .	216	134	9.50 a. m.	2.45	78.5	51.5	Do.

([1]) The *Italian State Railways* have 16 155 km. (10 034 miles) of standard gauge and 773 km. (480.3 miles) of narrow (0.95-m. = 3 ft. 1 3/8 in.) gauge lines.

Fig. 175. — 56-seater Breda railcar.
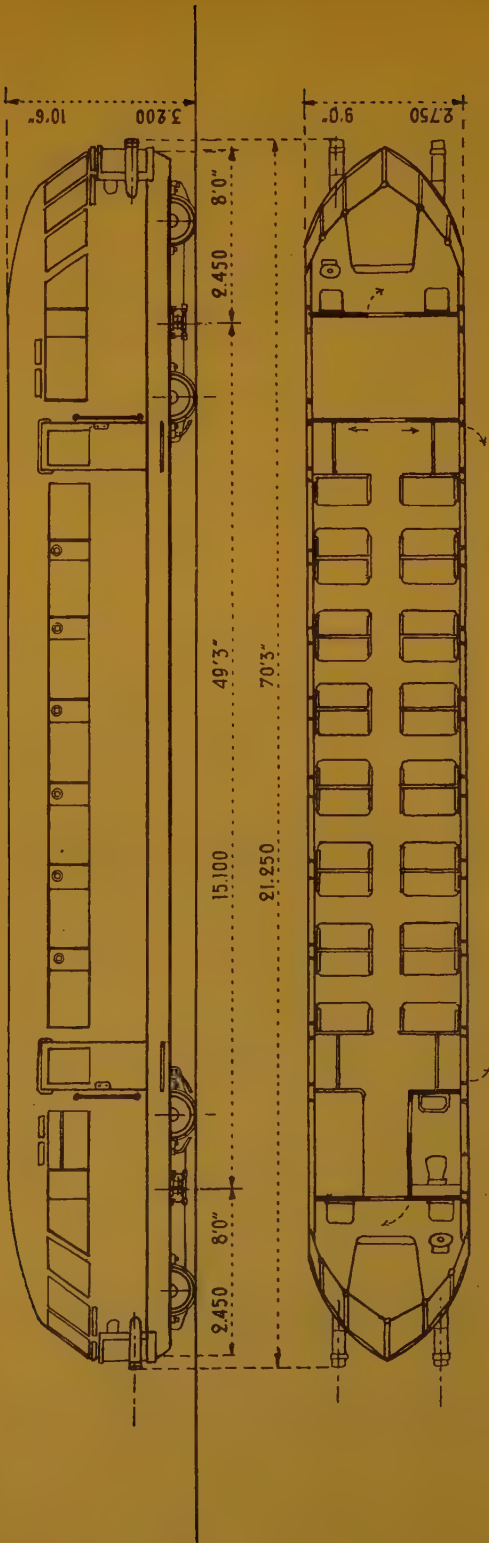
at the 1 340th km. (832.7 miles). This, with the line from Modane to Brindisi (1 239 km. = 769.9 miles) and to Lecce (1 227 km. = 794.8 miles), which is to be electrified as far as Bologna (at the 325th km. = 202 miles), is the longest in Italy.

Provision has also been made for electrifying the whole of the Rome-Brennero line (765 km. = 475.4 miles), only 187 km. (116.2 miles) of which are now electrified, and also the Turin, Milan and Fiume line (717 km. = 445.5 miles).

Various suburban lines are also electrically operated, particularly around Rome and Milan.

The only private electrified lines of any importance (apart from the secondary railways) are the following :

Rome-Viterbo . . . 102 km. (63.4 miles) [1]
S. Severo-Peschici .   79 km. (49.1 miles) [2]
Terni-Umbertide . . 108 km. (67.1 miles) [3]

The *Italian Rys.* have ordered from the Milan Ernesto Breda Works, six streamlined high-speed triplet articulated electric sets, which it will be most interesting to compare with the similar diesel sets about to be ordered as well, both having a maximum running speed of about 100 miles. The 3 000-volt D.C. electric sets are to run between Florence and Bologna and on to Rome and Naples as soon as electrification of these lines will have been completed.

With a weight of about 82 tons, they will seat 35 passengers in the leading 2nd-class- and kitchen coach, 35 first-class in the middle unit, and 24 second-class in the trailing coach and van unit.

---

[1] *Soc. Nord Romano*—High tension D.C.
[2] *F. e Trazione del Mezzogiorno*—High-tension D.C.
[3] *F. del Mediterraneo*—Single-phase.
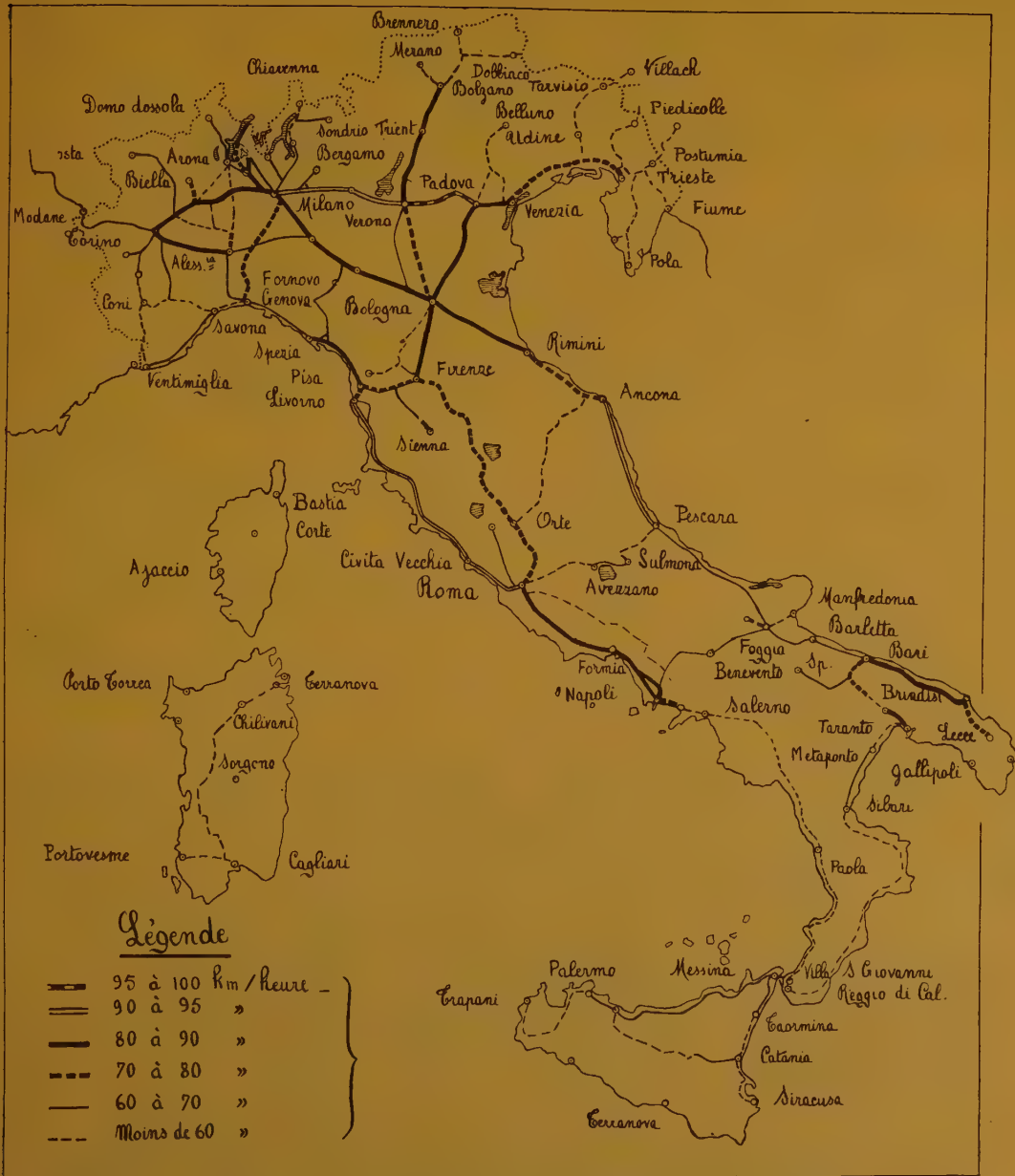
Fig. 176. — Map showing the speeds of the fastest Italian trains.

TABLE 175.

NOTEWORTHY ITALIAN TRAIN RUNS (fig. 176).

RUN.	Distance Km.	Distance Miles.	Time of departure.	Time spent.	Speed Km./h.	Speed Miles/h.	
Radiating lines.							
Modane-Turin-Genoa-Rome . . .	773	481	8.00 a. m.	11.10	69:2	43.0	« Paris-Rome Express »
Modane-Turin	106	66	Do.	2.00	54.0	33.6	Do.
Turin-Asti	56	35	10 10 a. m.	0.42	80.0	49.7	
Alessandria-Genoa P. P. . .	75	47	10.22 p. m.	1 13	61.7	38.3	All-sleeping-car train.
Genoa-La Spezia	87	54	12.02 a. m.	1.21	68.1	42.3	Do.
Leghorn-Rome	316	196	3.49 p. m.	3.21	94 7	58.8	« Paris-Rome Express »
Civita Vecchia-Rome	81	50	R 8 00 a. m.	1.09	70 4	43.7	
(Chiasso) Como-Milan	46	29	8 37 a. m.	0.40	69.0	42.9	
Milan-Bologna-Florence-Rome . .	633	393	R 10.30 a. m.	8.10	77.5	48.1	Rap. 23.
Milan-Bologna	219	136	7.00 a. m.	2.30	87.6	54.5	
Bologna-Florence	98	61	9.37 a. m.	1.06	89.1	55 4	Rap. 23, etc.
Florence-Rome	316	196	R 7.15 p. m.	4 18	73.5	45.7	
Chiusi-Rome	165	103	R 2 15 p. m.	2.12	75.0	46.6	
Milan-Fornovo-Rome	621	396	10.20 p. m.	10.15	60.6	37.7	All-sleeping-car train.
Fornovo-Viareggio	151	94	12.19 a. m.	2.13	68.1	42.3	Do.
Bolzano-Trento-Bologna	261	162	2.34 p. m.	3.23	77.6	48.2	Rap. 67, 2 stops.
Venice S. L.-Bologna	160	99	12 05 p. m.	2.00	80.0	49.7	Rap., 2 stops.
Rome-Orte (Ancona)	84	52	8.10 p. m.	1.03	80.0	49.7	Dmo. Venice.
Rome-Naples Cent.	214	133	9.05 a. m.	2.38	81.3	50.5	P. N. rap.
Naples-Mergelina	210	130	9.50 a. m.	2 45	76.4	47.5	Rap. 5.
Rome-Formia	129	80	11.20 p. m.	1.55	67.2	41.7	To Brindisi.
Rome Cassino-Naples	289	180	...	...	...	...	
(Rome) Naples-Foggia	198	123	3.05 p. m.	3.25	57.8	35 9	3 stops.
Benevento-Foggia	101	63	4.52 p. m.	1.38	61.8	38.4	
Rome-Naples-Siracusa							
Rome-Naples-Reggio Cal. . . .	696	432	9.00 p. m.	13.45	50.6	31.5	7 stops.
Naples Cent.-Torre Annunziata	22	14	10.25 a. m.	0.15	88.0	54.5	Railcar.
Salerno-Paola	220	137	12.56 a. m.	5.34	40.0	24.9	All-sleeping-car train.
San Eufemia-Reggio Cal. . .	128	80	R 11 05 p. m.	2.47	46 3	28.9	Do.
Transverse lines.							
Turin-Milan C.-Venice-Trieste . .							
Turin P. S.-Milan	147	91	12 15 p. m.	1.43	85.6	53.2	Rapido.
Milan C.-Venice S. L. . . .	267	135	11.57 a. m.	2.58	90.0	55.9	Do. 2 stops.
Venice S. L.-Trieste	157	98	R 4.10 p. m.	2.01	77.8	48.3	
Mestre-Trieste	148	92	10.04 p. m.	1.56	78 1	48.5	
Domodossola-Milan (Orient).							
Arona-Milan	69	43	8 59 a. m.	1.13	56.7	35.2	
(Milan) Bologna-Brindisi . .	761	473	3.25 a. m.	12.24	61.3	39.8	P. E. train.
Bologna-Rimini	112	70	Do.	1.22	81.9	55.9	
Turin-Ventimiglia							
Turin-Coni	88	55	4.20 p. m.	1.29	59.3	36.9	
Companies.							
Milan N.-Canzo . . . *Nord Milano.*	52	32	R 8.00 a. m.	1.00	52.0	32.0	4 stops.
Milan N.-Seveso	17	11	6.13 a. m.	0.16	63.7	39.5	
Milan N.-Camerlata	43	27	5.30 p. m.	0.40	64.5	40.2	
Milan N.-Saronno-Laveno N. . .	73	45	5.38 p. m.	1.18	56.2	34.9	
Milan N.-Varese N.	51	32	Do.	0.48	63.4	39.3	
Varese-Citiglio	18	11	6.27 p. m.	0 23	45.0	28.0	
Biella-Santhia . . . *Company.*	30	19	7.12 a. m.	0.27	66.7	41.4	

TABLE 176.

THE FASTEST ITALIAN TRAINS.

RUN.	Distance		Time of departure.	Time spent.	Speed		
	Km.	Miles.			Km./h.	Miles/h.	
Steam traction.							
Verona-Padua (Venice)	82	51	1 36 p. m.	0.50	98.4	61.1	Rapido.
Leghorn-Rome	316	190	3.49 p. m.	3.21	94.7	58.8	Rome Express.
Ancona-Pescara (Brindisi) . . .	240	149	6 16 a. m.	2.32	94.7	58.8	P. E. Rapido.
Milan-Verona (Venice)	148	92	11.57 a. m.	1.36	92.5	57.5	Rapido.
Pisa-Rome Term.	336	206	3.27 p. m.	3.43	90.4	56.1	P. R. Rapido.
Milan-Bologna	219	136	7 00 a. m.	2.30	87.6	54.5	Rapido.
Turin-Milan Cent.	147	91	12.15 p. m.	1.43	85.6	53.2	
Padua-Ferrara (Bologna) . . .	76	47	2.34 a. m.	0.54	84.8	52:7	Rapido.
Trento-Verona (Bologna) . . .	92	57	3.15 p. m.	1.06	83.6	52.0	Do.
Bolzano-Trento (Bologna) . . .	55	34	2.34 p. m.	0.40	82.5	51.1	Do.
Padua-Venice	37	23	2.27 p. m.	0.27	82.2	51.1	Do.
Bologna-Rimini	112	69	3.25 a. m.	1 22	81.9	50.9	Do.
Rome Tev.-Naples Cent.	...	...	9.05 a. m.	2.38	81.3	50.5	P. N. Rapido.
(Venice) Ferrara-Bologna . . .	47	29	R 8.00 p. m.	0.35	80.6	50.1	Rapido.
Venice-Bologna	160	99	R 12.05 p. m.	2.00	80.0	49.7	Do.
Rome-Naples Cent.	214	133	7 25 p. m.	2.40	80.0	49.7	Do.
Rome-Orte (Venice)	84	52	8.10 p. m.	1.03	80.0	49.7	Direttissimo.
Electric traction.							
(Milan) Bologna-Florence . . .	98	61	9.37 a. m.	1.06	89.1	55.3	Rapido.
Milan P. N.-Varese	59	37	9.01 p. m.	0.41	86.3	53.6	
Turin-Asti (Genova)	56	35	10.10 a. m.	0.42	80.0	49.7	
Naples-Villa Literno	30	19	10.08 a. m.	0.23	78 3	48.7	
Railcars.							
Naples C.-Torre Annunziata . .	22	14	10.25 a. m.	0.15	88.0	54 7	
Foggia-Cerignola Camp.	35	22	8.40 a. m.	0 24	87.5	54.4	
Bari-Brindisi	111	69	6.40 p. m.	1.20	83.3	51.8	
(Leghorn) Pontedera-Empoli . .	27	17	8.09 a. m.	0.20	81.0	50.3	
Turin P. S.-Chivasso	23	14	R 12.14 p. m.	0.17	81.2	50 4	
Foggia-Barletta	68	42	R 4.29 p. m.	0.51	80 0	49.7	
Pisa-Pontedera	20	12	7.53 a. m.	0.15	80.0	49.7	
(Bari) Castellanetto-Taranto . .	40	25	9.42 a. m.	0.30	80.0	49.7	

The total length over buffers is to be 62.86 m. (206 ft. 3 in.) (¹).

A five-minute service stop is allowed at Voghera (65th km. = 40.4 miles on the Milan-Genoa line), and at Villa-Li-terno (181th km. = 112.5 miles on the Rome-Naples line) to change an electric for a steam-locomotive or vice versa. Deducting this five-minute stop, the maximum average speed on these two lines

---

(¹) Over headstocks, the length is 62.50 m. (205 ft. 1 in.).

All bogies have 3.00-m. (9 ft. 10 in.) wheel base.

There are six motors, one 1 200-H.P. driving each of the middle bogies, and two 1 500-volt each of the end ones.

All bogie centres are spaced 17.500 m. (57 ft. 5 in.). Distance from outer bogie centres to ends of the set, 5.00 m. (16 ft. 5 in.), buffers excluded.

TABLE 177.

THE LONGEST NON-STOP RUNS.

RUN.	Distance.		Time of departure.	Time spent.	Speed.		
	Km.	Miles.			Km./h.	Miles/h.	
Steam traction.							
Leghorn-Rome	316	196	3.49 p. m.	3.21	94.7	58.8	Paris-Rome.
Florence-Rome	316	196	R 7.15 p. m.	4.18	73.5	.	
Ancona-Pescara (Brindisi) . . .	240	149	6.16 a. m.	2.32	94.7	58.8	P. E. Rapido.
Salerno-Paola (Reggio)	220	157	12.56 a. m.	5.34	40 0	24.9	All-sleeping-car train.
Milan-Bologna	219	136	7.00 a. m.	2.30	87.6	54.5	Rapido.
Rome Term.-Naples Cent. . . .	214	133	9.05 a. m.	2.38	81.3	50.5	P. N. Rapido.
Rome Term.-Naples Mergellina. .	210	131	9.50 a. m.	2.45	76.4	47.5	Rapido.
Pescara Cent.-Foggia	177	110	8 F 3 a. m.	2.58	60 0	37.3	P. E. Rapido.
(Florence) Chiusi-Rome	165	103	R 2. p. m.	2.12	75.0	46.6	
(Milan) Fornovo-Viareggio . .	151	94	12. . a. m.	2.13	68.1	42.3	All-sleeping-car train.
Venice S. L.-Trieste	157	98	R 4.10 p. m.	2.01	77.8	48.3	
Mestre-Trieste	148	92	10.04 p. m.	1.56	78.1	48.5	
Turin P. S.-Milan Cent.	147	91	12.15 p. m.	1.43	85.6	53.2	Rapido.
Milan Cent.-Verona	148	92	11.57 a. m.	1.36	92.5	57.5	Rapido.
Rome-Formia (Brindisi) . . .	129	80	11 20 p. m.	1.55	67.2	41.7	
(Naples) S. Eufemia-Reggio . .	128	80	R 11.05 p. m.	2.47	46.3	30.5	All-sleeping-car train.
(Milan) Foggia-Brindisi	123	76	11.56 a. m.	1.50	67.1	41.7	P. E. Rapido.
Verona-Bologna	114	71	4.27 p. m.	1.30	76.0	47.2	Rapido.
Milan-Bologna-Rimini	112	70	3.25 a. m.	6.22	81.9	55.9	
Electric traction.							
Rome-Term.-Naples Mergellina. .	210	131	9.50 a. m.	2.45	76.4	49 7	Mixed traction.
Milan-Genoa	149	93	12.10 p. m.	1.57	76.4	47.4	Do.
Modane-Turin	106	66	8.00 a. m.	2.00	54.0	33.6	Paris-Rome.
Bologna-Florence	98	61	9.37 a. m.	1.06	89.1	55.3	Rapido.
Alessandria-Genoa P. P.	75	47	10.22 p. m.	1.13	61.7	41.3	All-sleeping-car train.
Genoa-La Spezia	87	54	12.02 a. m.	1.21	68.1	42.2	Do.
Railcars.							
Bari-Brindisi	111	69	6.40 p. m.	1.20	82.3	51.8	
Pisa-Empoli-Florence	81	50	R 3.51 p. m.	1.15	64.8	40.3	
Foggia-Barletta	68	42	R 4.29 p. m.	0.15	80.0	49.7	
Bari-Gioia del Colle	54	34	8.39 a. m.	0.44	73.8	45.9	

is 79.8 and 81.0 km. (49.6 and 50.3 miles) an hour respectively.

XXXI-4. — **Rail ferryboats**. — Two services connect Italy with Sicily :

Villa San Giovanni-Messina Mar. . .	8 km. (5.0 miles)	0 h. 35	13.7 km. (8.5 miles) p./h.
Reggio di Calabria-Messina Mar. . .	15 km. (9.3 miles)	1 h. 00	15.0 km. (9.3 miles) p./h.

A quarter of an hour is allowed for embarking the passenger trains and five minutes for getting them ashore.

The service from Reggio di Calabria was started in 1890, and developed very rapidly. There are now some 15 daily

crossings each way, i.e. 6 via Reggio and 9 via Villa San Giovanni.

As the perishable goods have no longer to be handled on both sides of the Straits, working has been greatly facilitated and traffic accelerated; thus the 2 100 wagons transported during the first year increased to 20 788 in 1904, 44 890 in 1907, 92 017 in 1914 and 143 835 in 1925. At that time, five passenger trains crossed the Straits in each direction, which corresponds to some ten thousand coaches a year.

XXXI-5. — There are many **noteworthy Italian train runs.** We have grouped them, as usual in table form :

Table 175. — Interesting runs, classified by line.
Table 176. — The fastest runs.
Table 177. — The longest non-stop runs.

The latter have been divided into three groups : steam traction, electric traction, and railcars.

The largest tenders have a capacity of 22 m³ (4 848 Br. gallons) of water. In spite of this, some of the long non-stop runs include 3 or 5-minute service stops for taking water.

XXXI-6. — **Conclusions**. — The cartogram (fig. 176) shows all the Italian lines and the maximum overall speed of the trains running over them. If added up, in the various speed groups, the following figures are arrived at :

TABLE 178.

MILEAGE OF THE ITALIAN RAILWAYS
RUN OVER AT DIFFERENT OVERALL SPEEDS.

Miles.	SPEED.		Kilometres.	Percentage.
	Miles per hour.	Km./per hour.		
State Rys.			State Rys.	
	Over 62	Over 100		
51	59 to 61.9	95 to 99 9	82	1
476	56 to 58.9	90 to 94.9	766	5
967	50 to 55.9	80 to 89.9	1 557	9
523	44 to 49.9	70 to 79.9	842	5
1 043	38 to 43.9	60 to 69.9	1 677	10
6 979	Under 38.	Under 60	11 231	67
Companies.			Companies.	
286	...	...	459	3
10 321	TOTAL.		16 614	100

Over some two-thirds of the total mileage of the Italian railway system, the overall speed of the fastest trains is under 60 km. (37.3 miles) an hour; it only exceeds 80 km. (50 miles) an hour over less than one-sixth of the system.

(*To be continued.*)

IV–6

Occupation diagrams to facilitate the intensive use of platform roads in passenger stations,

by R. DEVOOGHT,

Engineer, Operating Department, Belgian National Railways Company.

Messrs. L. WEISSENBRUCH and J. VERDEYEN, in the September 1908 *Bulletin of the Railway Congress*, and Mr. A. PLATE, in the November 1912 number, have each described a diagram intended to represent not only the occupation of the platform roads in a station, but also to show all the movements of the trains, all shunts of engines and rakes, in order to bring out any movements which interfere with one another. The object of the present article is to compare these two diagrams and to suggest improvements which will enable them to be used generally, as well as more easily prepared.

In both diagrams, the vehicles can be distinguished by the kind and colour of the line representing them. For example, the trains can be shown by a black line, the rakes of stock by a blue line, and the locomotives by a red line. Shunting engines can also be shown by a special line, such as a broken red one.

Belgian diagram due to Messrs. Weissenbruch and Verdeyen.

Conventions :

1) Each platform road is shown by a double line; one indicating the *occupation* of the road by a *stationary* vehicle, and the other the vehicle moving over it. When the track is used solely as a running road, one line only is shown.

2) When the vehicle is moving over the running road, it can take either of two directions. The line on the diagram showing motion is always drawn from left to right to take into account the passage of time. This line should be marked with an arrow showing the direction the vehicle travels. The point of the arrow shows where the movement started or stopped.

A train running into the station therefore will be represented by :
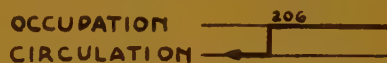
A locomotive going to the shed will be shown by :
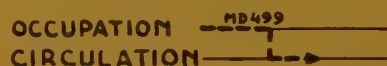
A rake taking the main line to release an engine and then setting back will be shown by :
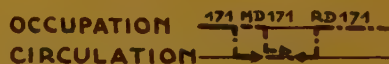
The length of the line indicating the time the train movement lasted has to show not only the time the vehicle took to cover the distance but also that between the route being decided (including the time taken getting it out) and that the vehicle cleared the last points and crossings of the route).

3) Messrs. Weissenbruch and Verdeyen show the number of the incoming or leaving track on the arrow. These numbers are selected in such a way that any possible interference is seen at once by merely reading the numbers.

Messrs. Weissenbruch and Verdeyen give no rules as to numbering the roads, but their examples show that the main lines are numbered with roman numerals or capital letters, beginning with the first met. Any transverse roads in the station are numbered with arabic numerals, those rising from left to right being numbered off from the extreme right-hand one, and those from right to left from the extreme left-hand one.

A route including a transverse road will be shown by inserting the number of the transverse road followed by the number of the departing main line besides the circulating line, or by the number of the entering main line followed by the number of the transverse road.

We will call *upper route* the route starting from the platform road with its circulation upright above that of a second route, in opposition to the latter known as the *lower route*. The train movements will not interfere when the number or numbers on the circulation line of the upper route are higher or lower than those on the circulation line of the lower route.

The authors looked for, and found, in the particular examples they have dealt with, the exceptions to the general rules they laid down. They have corrected these exceptions by artifices which unhappily are not at all general in character and are therefore difficult to apply.

We have endeavoured to make their method more general, and so more applicable to all cases.

PRELIMINARY REMARKS.

1) The plan of any station can always be reduced to the following layout.

— Main lines A, B, C, D, etc., numbered from below upwards run from one end into the station and either :

1. finish as a dead end;
2. finish as a platform road;
3. form a platform road and continue as a main line;
4. continue as a main line.

The main lines I, II, III, IV, etc., numbered from below upwards, leave the station after having :

1. started from a dead end;
2. started as a platform road;
3. been a main line and formed a platform road;
4. run through as a main line.

— Platform roads 1, 2, 3, 4, etc., numbered from below upwards, using arabic numerals. Each platform road cut by a transverse road then becomes a main line.

Any fixed plant (such as a shed, fan of sidings, etc.) is considered as a platform road when it reaches a main line without passing by a platform road and is only accessible from a platform road by setting back. It is considered as a main line in the contrary case.

— Transverse roads rising from left to right and numbered from right to left with odd arabic numerals, and transverse roads rising from left to right and numbered from right to left with even arabic numerals connect *at least* two main lines.

A transverse road need not necessarily be continuous : it can be made up of different sections, all having the same number from the moment these sections are set off in the direction they rise and

do not overlap. Some intermediate sections may even be missing entirely.

Each platform road is given in addition, in brackets, a capital letter to the left, and a roman numeral to the right.

This letter or numeral is that of the main line the platform road runs into without using any transverse road.

Example :
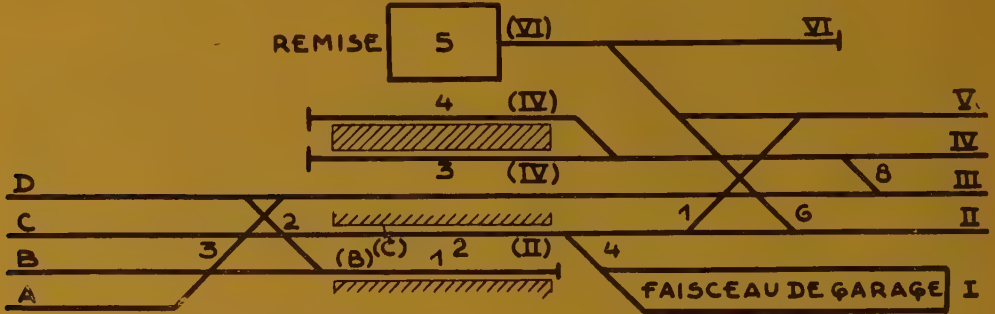
Note : Remise = shed. — Faisceau de garage = holding sidings.

2) When checking up to see the routes do not interfere with one another, the direction in which the train travels does not matter. We will therefore suppose that all the platform roads 1, 2, 3, etc. can be used by all trains, and vehicles leaving any platform road can run into any main line I, II, or III, etc. We will only consider the circulation on one side of the station, which corresponds to the case of a dead end station. In the case of a through station, two distinct diagrams are all that is needed or the diagrams can be superimposed, these diagrams having a common upright for the occupation of the platform lines, but separate uprights for the circulation towards one end and towards the other.

Each platform road has in principle a distinct circulation upright for a given end; but two or more platform roads which run into one another before meeting a transverse road are given a common upright.

Investigation into conflicting movements.

This enquiry can be based on the following premises :

1) Two vehicles ought not to be at the same time on one road, that is to say, two lines representing track occupation cannot be superimposed except in the following self-evident cases :

a) the two vehicles in question are short enough and can be accepted on the occupied track;

b) the two vehicles in question are additional vehicles, such as a locomotive and a rake intended to form a train;

c) the two vehicles are of different descriptions : the first, for example, does not run on Sundays; the second only runs on Sundays, etc.

Interference in this way is immediately evident.

2) Two routes cannot cross, or have a point or section in common, i.e., the upper route must always be above the lower, the levels being taken on the same vertical.

We will first of all deal with a particular case and then generalise.

PARTICULAR CASES. — Each of the two routes considered uses at most one transverse road.

FIRST CASE : The two vehicles do not run over any transverse road, i.e., their arrows carry only roman numerals.
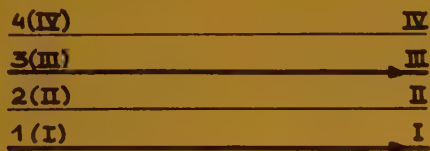
The two routes obviously do not conflict. The roman numerals must, of course, increase when read from below upwards.

SECOND CASE : The two routes each include a transverse road of opposite inclination :
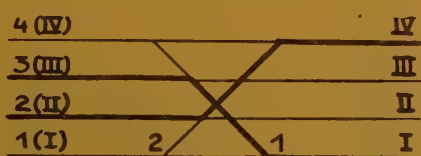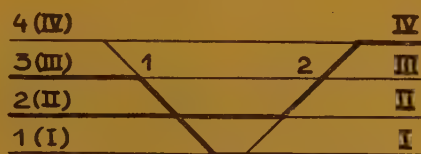
If the two routes are not to cross, the departure main line of the upper road must be above that of the lower departure main road.

The rule can be stated (provisionally).

Rule I : When two routes use two transverse roads of opposite inclination (one even arabic numeral, the second odd) the roman numerals of the arrows must — and this requirement is sufficient by itself — increase from below upwards for the two routes not to conflict.

THIRD CASE : The two routes each include a transverse road of parallel inclination.

It is no longer sufficient for the roman numerals to be in increasing order.
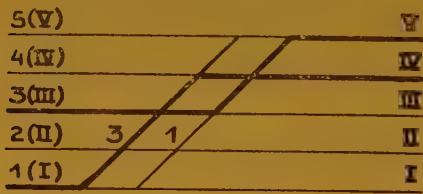
However, the following routes, starting and ending on the same tracks as the above example, do not conflict in any way.
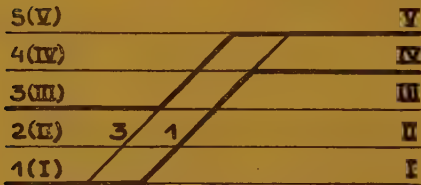
The movements are seen not to interfere with one another when the upper route ending in the upper departure main line also uses the odd number extreme transverse road (rising from left to right), no more than they are if the even number extreme right-hand transverse road (rising from right to left) is used. This is easily shown. So as to fix our ideas, let us take the transverse roads rising from left to right. As, starting from the right and going towards the left, these transverse roads are numbered by the odd arabic numerals increasing towards the left, we can state the rule.

Rule II : When two routes use two parallel transverse roads, all that is needed for them not to conflict is that the roman and arabic numerals be both in increasing order.

We use the expression « all that is needed » and not « they must », because, as we shall see later on (fourth case), there are routes which do not fulfil this condition, but do not conflict in any way.

FOURTH CASE : The two routes include the same transverse roads, or the numbers of the two parallel transverse roads do not increase. The interference can be due to the two routes having a point or a section in common.
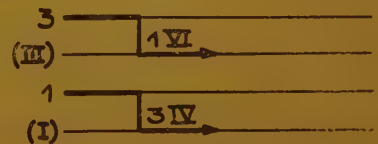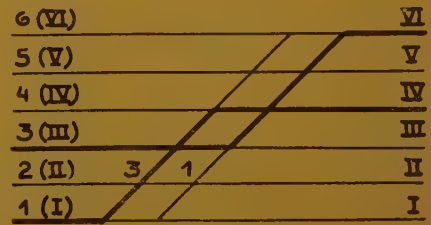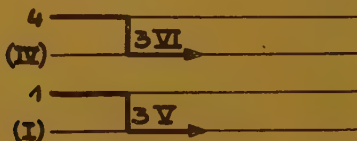
. Contrarily, the following routes do not conflict.
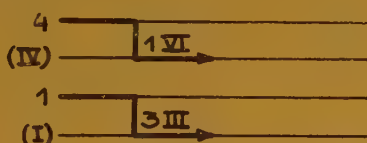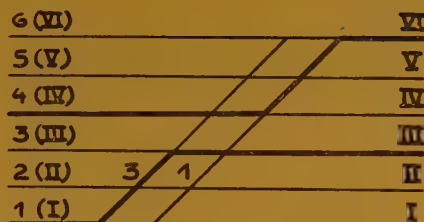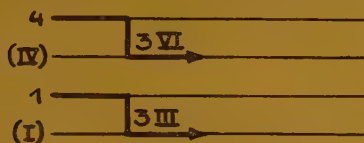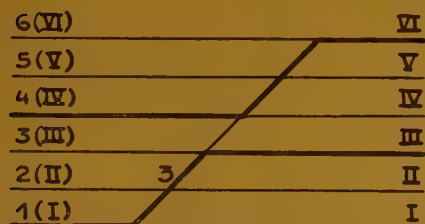
This case corresponds to the following phenomenon : the two routes are parallel at first, then one approaches the other, then the second leaves the first and the two again become parallel. The two roads will not have a common point provided the highest track of the lower route is lower than the lowest track of the upper route.

The following remark may be made here : if the top road of the lower route is below the bottom road of the upper route, the general condition can be laid down that the departure and outbound tracks of the lower route must be below those of the upper route. This general statement has the advantage that the inclination of the transverse roads need not be considered.

Let us mark on our diagram, in line with the circulation uprights, besides the arabic numerals of the platform roads, the roman numeral we have written in brackets on our station plan.

The two roman numerals of the lower arrow, i.e. the roman numeral between brackets at the end of the upright and the roman numeral at the end of the arrow, should be lower than the two roman numerals of the upper arrow.

Now, the roman numerals between brackets are obviously rising, and a priori the roman numerals at the ends of the arrows must also increase. All that is required, therefore, is to see that the lower right hand numeral is rising, with the left hand upper numeral, and that the lower left hand numeral also increases, with the right hand upper numeral, i.e. to carry out a *cross check*.

We can therefore lay down the following rule for interference :

RULE FOR INTERFERENCE (one transverse road at most).

Two arrows are situated one above the other.

First question : Are the roman numerals in rising order ?

Answer : No : the routes conflict.

Yes : then,

Second question : Are both arabic numerals evens or odds ?

Answer : No : the routes do not conflict.

Yes : then,

Third question : Are the arabic numerals in rising order ?

Answer : Yes : the routes do not conflict.

No : then,

Fourth question : Do the roman numerals increase crosswise ?

Answer : Yes : the routes do not conflict.

No : the routes conflict.

GENERAL CASE : One at least of the two routes considered uses several transverse roads.

Remarks :

1) Such a route can be described as follows : the vehicle leaves the platform road, runs over a transverse road on to a main line, which it then leaves, takes a transverse road on to another main line; it then leaves this main line by a transverse road for a third main line and so on.

The complete route can be subdivided into part routes generally composed of part of a transverse road and part of a main line. A partial route of this kind will be called a « section ». It is shewn on the circulation arrow by an arabic and a roman numeral.

The first section formed by the platform road can be taken as consisting of a main line section, with the roman numeral inscribed between brackets against the upright of the platform road. This section is therefore marked off beforehand and is not inscribed on the arrow which must not be taken as meaning that the rules we are about to state do not apply to it.

A section of the upper route will be an « upper section », as opposed to a « lower section ». A lower section will be designated by aA, an upper section by bB, a and b being arabic numerals and A and B the roman.

A section starting with an even number transverse road will be an « even section » as compared with an « odd section ».

In the left to right direction (roman numerals) :

the first lower section is to be taken as being even,

the first upper section is to be taken as being odd.

In the right to left direction (capital letters) the opposite is the case.

2) Two numerals make an increasing couple when that of the upper route is greater than that of the lower.

The most unfavourable case as regards non-interference is when the two numerals are equal.

In the case of the arabic numerals, the convention is that a couple shall always be formed of not more than two even or two odd numerals. In other words in a couple of arabic numerals :

$$b — a = 2\ n.$$

If n is nil or positive, the couple is an increasing couple. If n is negative, the couple is a decreasing one.

3) If the roman numerals at the ends of the arrows do not form an increasing couple, we can conclude at once that the routes conflict.

4) To check that the two complete routes do not cross, all that has to be done is to make sure that no lower section cuts any upper section.

5) We can neglect some of the crossings, provided we are certain another crossing will be brought to notice later on or has been already.

We can therefore ignore all cases with B greater than A. In fact :

1. either there has been no crossing, or

2. there was a crossing, but B become greater than A, the upper section was below the lower section, i.e. there was a previous crossing with B less than A this time.

If therefore the roman numerals of the two sections form an increasing couple, we can considerer the routes as not conflicting.

We have, therefore, only to consider the possibility of B being smaller than A.

FIRST CASE : *The sections are both even or odd :*

$$b - a = 2 \, n.$$

We move along the lower route (lower arrow) from left to right, examining all the sections and checking their compatibility with the upper sections which, like them, are evens or odds and have smaller roman numerals.

1) b is smaller than a, i.e. the arabic numerals form a decreasing couple :
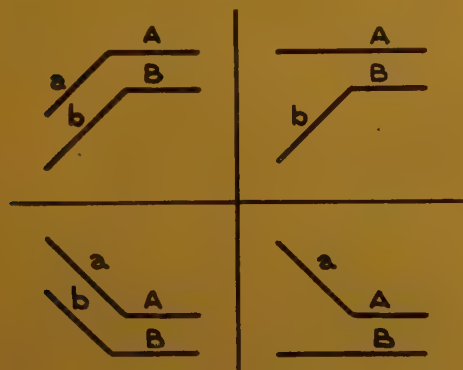
The figures show that the two sections do not cross.

2) b is equal to or greater than a, i.e. the arabic numerals form an increasing couple :
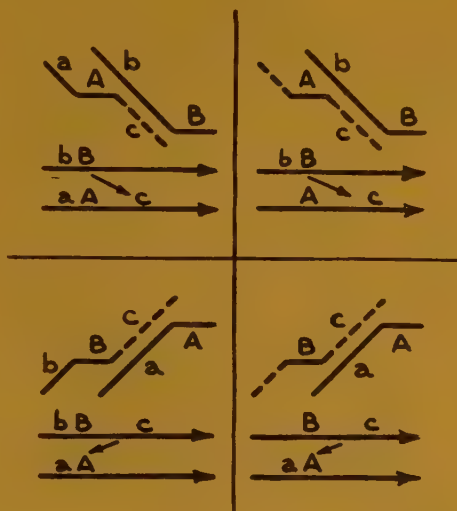
The figures show that if the two sections are not to cross, we must have

$$a < c < b.$$

First general rule.

When examining, moving from left to right, the non-interference of the even sections with one another, and of the odd sections with one another, the roman numerals of which decrease, *all that is required* is that the arabic numerals form a decreasing couple. If the couple is an increasing one, an arabic numeral respectively odd or even which with the other arabic numeral also forms an increasing couple *must* be found *to the right* of the odd upper arabic numeral or to the right of the even lower arabic numeral.

SECOND CASE : *The sections are not both even or odd :*

$$b - a = 2\,n + 1$$

1) *a* is even.
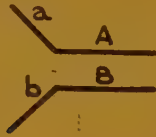
The figure shows that the two sections do not cross.

2) *a* is odd.
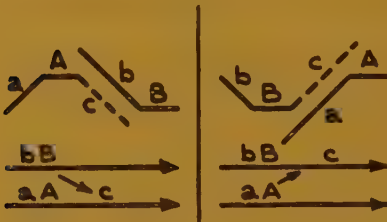
The figures show that to prevent the paths crossing, *c* must be $< b$, or $c > a$.

Second general rule.

If we examine, from left to right, the non-interference of the odd lower sections with the even upper sections, the roman numerals of which form a decreasing couple, we must find, to the right of one of the arabic numerals, another arabic numeral which, with the second arabic numeral, forms an increasing couple. The even numerals are to be looked for on the lower arrow, and the odd numerals on the upper arrow.

First sections.

This justifies the assimilation, for the left to right direction, of the first lower section to an even section. We can, in fact, imagine an odd transverse road and an even one before this section. The odd imaginary transverse road will be greater than any actual one, and will therefore form with it a decreasing couple. This case eliminates itself and there remains an even section with arabic numeral smaller than any other.

That the first upper section is an odd section with an arabic numeral larger than any other is shown in the same way.

SINGLE GENERAL RULE.

Preliminary question : Are the end roman numerals increasing,

Answer : No : the routes conflict.

Yes : then,

Move from left to right along the two arrows.

Only compare sections with decreasing roman numeral couples.

Compare the even lower sections with the even upper sections.

Compare the odd lower sections with all the upper sections.

First question : Do the arabic numerals form a decreasing couple ?

Answer : Yes : the sections do not interfere with one another.

No : then,

Second question : Is there, to the right of one of the arabic numerals, another forming with it an increasing couple ?

Answer : Yes : the sections do not conflict.

No : the sections do conflict.

Remarks :

1) It is easy to see that the particular case is covered by the general one.

2) The general rule is only applicable in some rare cases, generally, moreover, simple ones. We have given it, however,

for the sake of completeness and also because it enables us to represent, in a simple way, limited movements.

Limited movements.

By limited movement is meant the circulation of a vehicle which does not leave the station, but stops before a transverse road. A complete movement, therefore, consists of two such partial movements but in opposite directions. If this route be described as being complete, i.e. without stating that the last section of main line does not extend beyond station limits, we will be led to consider the other routes using the transverse roads not run over or cut by the limited route considered, as interfering with the said limited movement. The difficulty can

be removed by considering this limited path as extending itself by an odd transverse road preceding the odd transverse roads not engaged, and by one even transverse road preceding the even transverse roads not engaged.

This imaginary section has no roman numeral. It can be given, therefore, a roman numeral large or small enough, according to the case, so as to get with any other section an increasing couple of roman numerals.

The result is that it is unnecessary to check the imaginary section to see it does not conflict with the others. It only exists to remove, by one of its arabic numerals, any interference between two ordinary sections.

Examples showing limited movements.
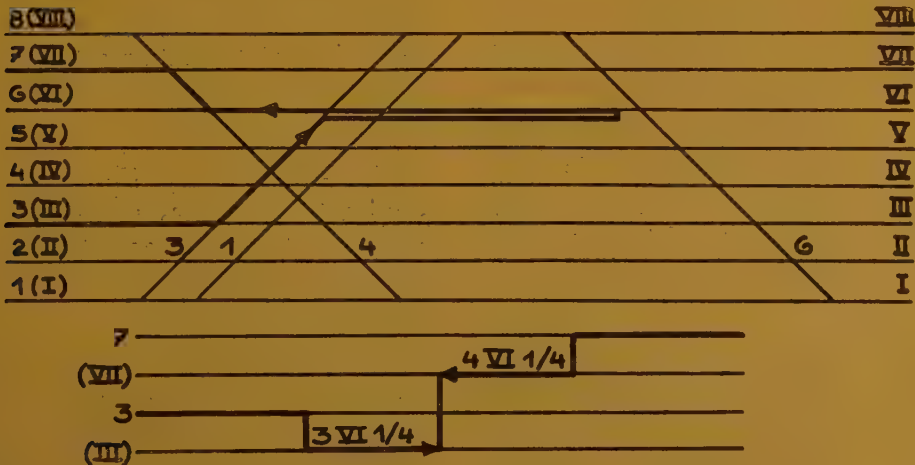
An imaginary section ending a limited movement is represented therefore by two arabic numerals, one even, the other odd, separated by a fraction bar.

Imaginary transverse roads.

When applying the rule, when a movement stops before a transverse road m,

there must be a transverse road m-2 in the station. This is the case notably when the even and odd transverse roads lie on both sides of the platform roads. Otherwise, if when numbering the transverse lines we come to a platform road before meeting a transverse road, the first numeral, even or odd as the case may be, would be reserved for the imaginary transverse line and this makes it possible to show the limited movements.

Divided routes.

The above method cannot take into account the facilities in station working due to dividing the route into one or several zones limited by signals or by route end pedals.

Practical rule for applying the improved Belgian diagram.

1) Draw a diagram of the station in question with horizontal lines for the running lines on both sides and the platform roads, and inclined lines for the single crossovers and transverse lines.

2) Number from the bottom line upwards, with arabic numerals, the platform roads and fixed plant (such as shed, sidings, etc.) which lead to a main line without passing by a platform road and which can only lead to a platform road by setting back.

3) Number from the bottom upwards, using capitals A, B, C, etc. to the left and roman numerals I, II, III, etc. to the right, the main line and the fixed plant (shed, shunting sidings, dead end road, etc.) directly accessible from a platform road without a back shunt.

4) Number the transverse roads, i.e. the roads connecting at least two main lines, rising from left to right, with odd arabic numerals commencing with the righthandmost, and the transverse roads rising from right to left with even arabic numerals commencing with the lefthandmost road. If before meeting a transverse road, a platform road is encountered, reserve the first number.

5) Give each platform or similar road a capital letter to the left and a roman numeral to the right, each in brackets. This letter or numeral is that of the main line which the platform road joins up with, without using any transverse road. This letter or numeral may be wanting.

6) Draw a diagram with an occupation upright for each platform road, the uprights following one another in the order the platform roads are numbered. Draw below each occupation upright a circulation upright from the left to right direction (roman numeral) and above it a circulation upright for the right to left direction (capital letter). There may be a circulation upright wanting.

Two or several platform roads which connect up before meeting a transverse road are given a common circulation upright.

7) Mark (between brackets in a special colour) along each circulation upright, in the left upper angle formed by the verticals for the whole hours, the capital letter or roman numeral which is entered in the coresponding direction on the station diagram — see (5).

8) By different lines or lines of different colours according to the kind of vehicle, mark in the occupation on the occupation uprights, and the circulation on suitable circulation uprights. The time of circulation has been defined earlier. The arrow indicates the direction of movement. The arabic and roman numerals entered along the arrow indicate the section run over in order, the

vehicle being supposed to be going from the platform road towards the main lines.

Non interference.

1) Compare the inscription of two arrows lying one above the other on two circulation uprights for the same direction.

Note : Replace, if need be, a roman numeral by a capital letter.

2) Question. Are the roman numerals at the ends in ascending order ?

Answer. No. There is interference: search completed.

Yes; then continue either if each road has at work at most one transverse road, by the particular rule, or, unless preferred in all cases, by the following method.

3) Follow the two arrows from left to right, only compare the section with decreasing couple of roman numerals.

Compare the lower even sections with the upper even sections; the lower even sections with all the upper sections.

First question : Do the arabic numerals form a decreasing couple ?

Reply : Yes : the sections do not interfere; continue.

Second question : Is there to the right of one of the arabic numerals another arabic numeral, forming with the second an increasing couple :

Answer : Yes : the sections do not interfere; continue.

No : interference, search completed.

The first section is always formed of a single roman numeral between brackets, and the lower section is considered as being even and the upper as odd, when the movement is to the right hand side of the station, otherwise the opposite.

A section composed of two arabic numerals indicates a limited movement. It can only be used to remove interference; never to cause it.

Examples :

Routes conflicting :

a)	(V)	4II	3VI	8II
	(IV)	2 I	1IV	6III
b)	(V)	4II	**3IV**	6III
	(IV)	2 I	**1VI**	8II
c)	(V)	**4II**	1VI	8III
	(IV)	2 I	**3IV**	6 II
d)	(V)	**4 I**	3VI	8III
	(IV)	**2II**	1IV	6 II
e)	(V)	**2 II**	3VI	8III
	(IV)	4 I	1IV	6 II
f)	**(V)**	6III		
	(IV)	2II	**3VI**	8II
g)	(V)	4II	**3IV**	6III
	(IV)	2 I	**1VI**	1/4
h)	(V)	4II	**3IV**	1/6
	(IV)	2 I	**1VI**	6III

Routes not conflicting :

i)	(V)	4II	3VI	8III
	(IV)	2 I	1IV	6 II
j)	(V)	4II	3IV	3/4
	(IV)	2 I	1VI	6III

Dutch diagram due to Mr. A. Plate.

Mr. A. Plate, Engineer of the Netherlands Railway Company, describes his diagram as follows :

CÔTÉ VOIES À QUAI

CÔTÉ VOIES PRINCIPALES
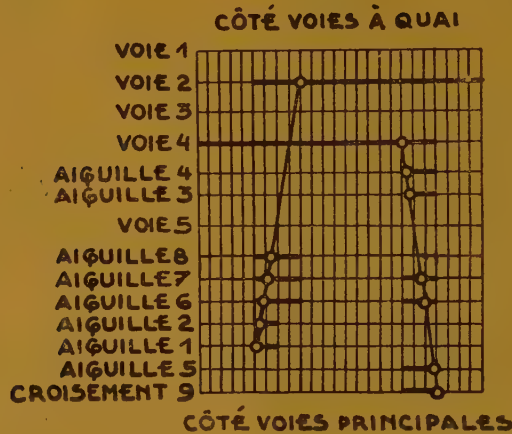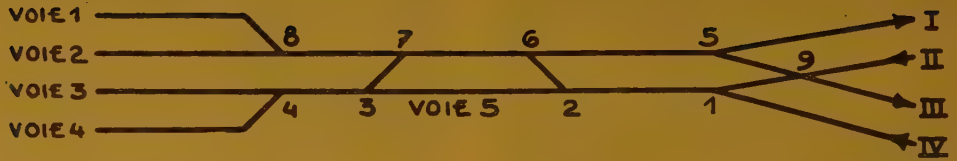
Explanation of French terms :
Voie = line. — Côté voies à quai = platform roads side. — Côté voies principales = main lines side. — Aiguille = point. — Croisement = crossing.

Horizontal lines represent the various points and crossings described by their numbers. Vertical lines shew the time in minutes. A train movement is represented by marking all the points and crossings it passes over.

A heavy horizontal line indicates the time each switch is occupied by the passing train. The order in which each of the points is run over is shewn more closely by oblique lines. The points of intersection of these oblique lines with the horizontal lines representing the points run over are marked by small circles. The running tracks can be represented by horizontal lines to make the diagram more complete or clearer.

Mr. Plate adds : « The diagram is made still clearer if the order in which the points numbers follow is so fixed that the arrival and departure of a train is represented as far as possible by a straight line and not by a broken one. » This seems to suggest that it is not always possible to use a straight line in this way, and the example he gives to illustrate the method confirms this, as there are several broken lines in it.

We have endeavoured to devise a method whereby the horizontal lines representing the points and crossings and the tracks are arranged in such order that the arrival or departure of a vehicle is *always* represented by a straight line. This line rises when the vehicle moves in one direction, and falls when in the other. The line, therefore, is only broken when the movement involves setting back. The

diagram therefore shows the rythm of the movements very clearly.

Let us take a certain station. At one end there are the main lines A, B, C, etc. and at the other the main lines I, II, III, etc. Between these are the platform roads 1, 2, 3, etc. We will run through the station from the ends of lines I, II, III, etc. towards the ends of A, B, C, etc.

Let us follow any given route. Suppose we come to the points A_n the horizontal line representing which is taken as being at the proper level, i.e. above all the horizontal lines representing all the points and crossings of all routes leading to A_n.

We then meet points A_{n+1}.

Case 1 : The switch A_{n+} is taken facing.

As every route leading to A_{n+1} has to pass by A_n, the horizontal line A_{n+1}, if above the horizontal line A_n, will be above the horizontal lines of all the switches preceding A_{n+1}.

Therefore, it is necessary and meets requirements that the horizontal line of a switch taken facing be above the horizontal line of the immediately preceding switch. Its level is not fixed in any other way.

Case 2 : The switch A_{n+1} is taken trailing.

The horizontal line A_{n+1} ought to be above the horizontal line A_n, and thereby will occupy the proper position relatively to the horizontal lines of the routes lead-to A_n. These routes, however, are not the only ones leading to A_{n+1}. There are also those of the other branch, that is, B_n and those before it. The horizontal line A_{n+1} therefore must be above the horizontal A_n and also above the horizontal B_n. Consequently the first time we meet A_{n+1} when coming from A_n, its horizontal line is only drawn in provi-

sionally. We only draw in the horizontal line A_{n+1} above the horizontal line B_n definitely when, *later on*, we arrive at A_{n+1} via B_n. It will then be above both B_n and A_n.

. *Remarks*.

1) Slip points are taken both facing and trailing. As they are only represented by a single horizontal line, and as points taken trailing cause greater restriction in the working than when taken facing, we will suppose them taken trailing.

Crossings will also be considered as being taken trailing.

2) Two switches arranged point to point may be given a common upright.

To illustrate our method, we have taken Rotterdam D. P. station a « Dutch diagram » for which was given in Mr. Plate's article, figure page 440.

Practical rule for applying the improved Dutch diagram.

Take the diagram of the station considered with the numbers of all the switches, main lines at both ends of the station and of the platform roads. A figure taken from the continuous numbering indicating the level of the horizontal representing these switches or these roads, must be inscribed beside these numbers.

Consider the right-hand side of the station : number the main lines on this side commencing say with the top line above. Number all the tracks, also considering as a track a fan of sidings or a dead end track. Travel from right to left over the main line No. 1 and in turn over all the branches which turn out of it at the facing points it contains. Travel first of all over the righthandmost branch. Stop the various branches at the first
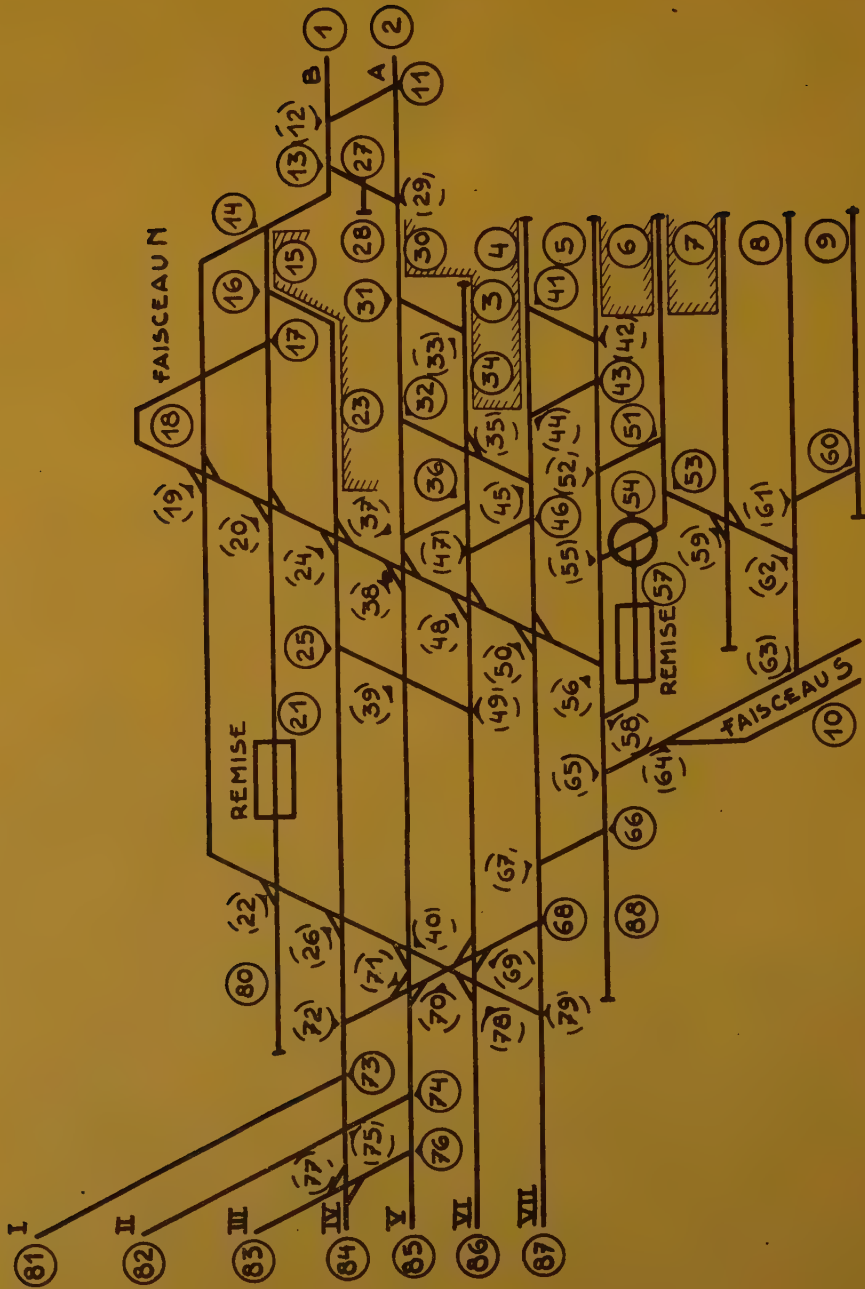
Diagram of the road in the Rotterdam D. P. station with the numbers of the switches and tracks.

Note: Remise = shed. — Faisceau N (S) = North (South) sidings.

point taken trailing. Each time a point taken facing is encountered, or a section of platform road, give it a number in a circle (for the sake of clearness a full circle is used here). When a set of trailing points is encountered, only shew the circle (for clearness, by a dotted line). If it already has a dotted circle, and only then, enter a number and continue to number off beyond. When all the branches off the main line No. 1 are used up, that is to say end by a circle or by the last points at the other end of the station, take main line No. 2, and all the other main lines, and deal with them in the same way. Finally, number off the main lines at the other end of the station.

Prepare a diagram with the number of horizontal lines given by the last number used. Number these horizontal lines upwards, the bottom line being No. 1. Enter, facing each horizontal line, the number of the points on the track with the corresponding number.

Mark under the horizontal line No. 1 « Station side X », X being the right-hand side of the station.

Above the topmost horizontal line mark « Station side Y », Y being the left-hand side of the station.

Comparison of the two methods.

1) The above investigation shews clearly enough that the Dutch method has the advantage of simplicity. It is possible to understand its principles without long explanations. It is, in fact, the best graphical method of showing train movements which comes to mind.

Simplicity of principle, however, is only an accessory advantage compared with simplicity and ease of use.

If the Belgian diagram proved better from this point of view, there would be no reason why those using it should not make the necessary effort to understand it.

2) There is no difficulty in making the diagram if the principles laid down above are followed. The difficulties, however, are rather greater with the Belgian diagram.

3) The size of diagram to use is much greater in the case of the Dutch diagram than with the Belgian, which might make it difficult to use the former in large stations.

4) A given route is longer on the Dutch than on the Belgian diagram. Each point in the route must be located and the time of occupation shewn. The line representing the arrival and departure of a train runs almost across the whole of the diagram vertically. As a rule, however, it is sufficient to join the circle indicating when the first switch was occupied to the circle marking when the last point was cleared, without showing the occupation of the intermediate points. The only risk there is of any interference is when two inclined lines cut the same vertical and then the two routes must be drawn in completely.

5) Against this, the Dutch diagram requires little if any writing, unlike the Belgian.

6) With the Dutch diagram, it is possible to use the operating facility of being able to divide the routes into sections.

7) The Dutch diagram also makes it possible to see at a glance which movements are made impossible should any particular set of points get out of order. It also shews the points and crossings most frequently used.

Conclusion.

Each method has its own useful applications. Experience, however, shews that the Belgian diagram can be of great service, especially in the following cases :

1) The station layout is comparatively simple, i.e. has long but few transverse roads.

2) Certain routes cannot be used owing to the kind and arrangement of the points, and this eliminates the most serious cases of interference.

3) The routes which can be set up in the signal box never use more than one transverse road.

4) The facility obtained by dividing up the routes is not used, and this gives some elasticity in meeting possible contingencies.

The hunting of railway vehicles,

by Carlos LAFFITTE-MARTINEZ,
Industrial Engineer.

Introduction.

The motion of rolling stock, known as hunting, interferes with the smooth riding of the stock, and has been the subject of investigations since the early days of railways. In early days, it was attributed to the inertia forces set up by the reciprocating parts of the engine; it was soon seen, however, that single coaches or wagons hunted when running by themselves, and later on that electric locomotives which have no alternating parts also hunted.

This motion was ascribed subsequently to the conicity of the tyres which, in fact, does play a large part in it, though not a primary one. Marié quotes, in this connection, the case of railway vehicles with wheels free to revolve on the axles instead of being rigidly fastened thereto, thereby eliminating the effect of the conicity of the tyres; the rolling stock thus equipped still hunted. The explanation is really quite simple. Owing to the play between the wheel flanges and the rails, the vehicle takes up an oblique position relatively to the centre line of the track and, whilst running in this way, a flange of the leading pair of wheels strikes the corresponding rail and the blow throws the vehicle across in the opposite direction. The other flange in turn strikes its rail and the phenomenon is repeated, becoming periodic in certain circumstances.

This explanation applies to the tapered tyre as well as to the cylindrical one, with both of which hunting takes place.

Theory of hunting.

If we consider the displacement, on the track, of a single pair of wheels with coned tyres, we see, when the centre of the axle does not coincide with the centre line of the track, that, as the radii of the rolling circles are not the same, the centre of the axle describes a curve the radius of which, when the axle is in a normal position relatively to the track, is that of the circumference of the rolling circle without any slip; that is to say :

$$R = \frac{r}{a} \frac{b}{i} \qquad (1)$$

in which r = radius of the wheels,
$\qquad i$ = taper of the tyres,
$\qquad a$ = distance between the centre of the axle and the centre line of the track,
$\qquad b$ = gauge.

As the axle continues its movement, the radius of the rolling circle of the outer wheel on the curve becomes smaller, and that of the inner wheel greater; the result is that the radius of curvature increases to infinite, when the radii of the rolling circles become the same, and change sign when the radius of the smaller rolling circle becomes the greater, and *vice versa*.

The curve described is evidently sinusoidal, the radius of curvature at the summits being given by (1); the period of the curve in question will be

$$D = 2\pi \sqrt{\frac{r\,b}{i}} \qquad (2)$$

With the usual railway loading gauges and the standard track gauge, the length D is about 24 m. (78 ft. 9 in.).

The full demonstration of formula (2) is found in CARTER's « *Railway Electric Traction* » and in a paper by Mr. MAUZIN : « Etudes sur le lacet des véhicules » (Investigation into the hunting of railway vehicles), printed in the *Revue Générale des Chemins de fer* (January 1933).

Both these authors investigated the movement of a bogie or four-wheeled coach and developed the following formula for the period :

$$D = 2 \pi \sqrt{\frac{r\ b}{i} \times \frac{b^2 + c^2}{b^2}} \qquad (3)$$

in which b = half the gauge of the track and c = half the bogie or vehicle wheel base.

This gives, for an ordinary bogie of $2\ c$ = 2.50 m. (8 ft. 2 7/16 in.) wheel base, D = 30 m. (98 ft. 5 1/8 in.). By experiment, the value found was D = 25 m. (82 ft. 1/4 in.), which is less than that given by equation (3) and nearly the same as that given by equation (2).

It should be noted that, in the investigation, the inertia forces were not taken into account, neither in the case of the single pair of wheels nor that of the bogie. Taking the separate pair of wheels, the centrifugal force increases with the amplitude of the oscillations, and CARTER shows that, generally speaking, this amplitude increases until periodic shocks are set up between the flanges and the rails, as is confirmed moreover by experience.

Whether the tyres are tapered or not, care is always taken to prevent the shocks becoming periodic although the theory set forth does not take them into account. These shocks, in conjunction with other inertia forces also ignored, explain the difference between the results given by formula (3) and those obtained experimentally. With the bogie mentioned, the difference is not great as the shocks are not very severe in the case of bogie passenger vehicles, which are usually light in weight and can be considered as isolated from the body transversely, thanks to the swing links usually fitted. When driving bogies or vehicles are in question, the effect of the shocks can be extremely great and make formula (3) inapplicable.

The formulation of a strict theory of this action is very complex. The formulæ suggested by the authors whose works we have examined are really empirical, owing to the simplifying hypotheses they have resorted to. This is true of Mr. POCHET's formula, given in his paper on the « Theory of the motion of railway vehicles on curves », as of the almost identical formula proposed by Mr. MARIÉ in his pamphlet on hunting. The latter formula is :

$$T = 3 \sqrt{\frac{2\ \varepsilon}{K\ g\ f}} \qquad (4)$$

in which T = the period of hunting in seconds,

f = coefficient of friction between the tyres and the rail = 0.20,

K a constant = $\begin{cases} 0.50 \text{ for locomotives} \\ \quad \text{and vehicles of old} \\ \quad \text{types (light)}; \\ 0.40 \text{ for heavy loco-} \\ \quad \text{motives}; \\ 0.30 \text{ for bogie coaches.} \end{cases}$

From formula (4), T is independent of the speed. The author points out, however, that it only applies to speeds of about 100 km. (62 miles) an hour, so that it is merely an empirical formula in rather close agreement with the results of everyday practice. We think it does

not agree with practical results as regards the effect of the play in the track on the values of T and D. Formula (3) gives values independent of ε, and we consider that the effect of the play on the value of D, if any, is less than that given by formula (4).

The foregoing shows that there are divergences of opinion as regards the problem we are considering, which are due to the fact that the mathematical study has not been carried sufficiently far, at least by the authors consulted. This is explicable, moreover, as the problem is extremely complex. We do not pretend to have solved it, and we will examine only one of its aspects, a simple one which takes into account the forces due to shocks and to friction, in the direction of the hunting motion, and ignores the opposing frictional forces. This will give an amplified image of the effects of the shocks, quite ignored in earlier investigations, and we shall be able to formulate a few interesting conclusions.

A simplified theory of hunting.

Let us suppose a single vehicle moving regularly along a straight section of line without its buffing and draw gear in any way preventing the oscillations known as hunting. Let us assume, moreover, that its centre of gravity coincides with that of figure 1, and let us represent diagrammatically the axles by the straight lines AB and CD, the wheels being shown by the letters A, B, C and D.
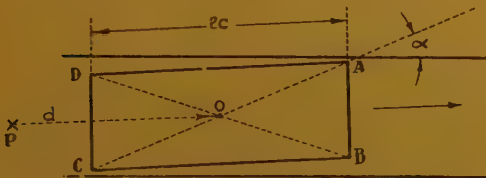
Fig. 1.

The wheel base is $2c$, the gauge of the track $2b$, and the distance apart of the outside faces of the wheel flanges AB, a certain amount of play between $2b$ and AB being designated by 2ε. Let α be the angle (supposed small) between the centre line of the vehicle and that of the track, at the instant the flange of a wheel strikes the corresponding rail, ω be the angular velocity of the vehicle at the same moment, u its transverse speed, and V the speed of translation of the vehicle. .

For the phenonemon to be periodic, u, ω and α must retain the same values for every shock; in this way, the angular velocity remaining the same as well as the resultant angular velocity which equals $u + V\alpha = u + v$, (taking $V\alpha = v$), the shocks will occur under identical conditions, and the phenonemon will repeat itself periodically.

In the absence of any resistance, since those due to friction are ignored, u and ω remain constant between two shocks, and only change direction with the shocks.

In this way we arrive at the formula :

$$(u + v + \omega c)\, e = u + \omega c \qquad (5)$$

which shows that the speed of the point A before the shock, multiplied by the coefficient of reaction e, equals the speed after the shock.

The theory of percussion will give us another equation of these values. We know that the speed of this point remains unchanged after the shock. If P be the centre of percussion (fig. 1) and d its distance from the centre O given by the equation $\rho^2 = d\,c$ (ρ = radius of gyration), we have

$$u + v - \omega d = \omega d - u \qquad (6)$$

which expresses the equality of the speeds of the point P before and after the shock.

If we take $\dfrac{\rho^2}{c^2} = K$,

we obtain $d = \dfrac{\rho^2}{c} = K\ c$ (7)

and $c + d = (1 + K)\ c$ (8)

From formula (6) we obtain

$$u = \omega\ c\ K - \frac{v}{2} \qquad (9)$$

which, substituted in (5), gives

$$\omega = \frac{v}{2}\ \frac{1 + e}{c\,(1 + K)\,(1 - e)} \qquad (10)$$

To ascertain the length of the periodic movement D we have, T being the period,

$$D = VT \quad \text{and} \quad \omega\,\frac{T}{2} = 2\,\alpha$$

as the vehicle will have described the angle $2\ \alpha$ at the middle of the period.

From these equations,

$$D = \frac{4\ v}{\omega} \qquad (11)$$

and, therefore,

$$D = \frac{8\ c\ (1 + K)\ (1 - e)}{1 + e} \qquad (12)$$

This formula gives us the amplitude of the movement in terms of known quantities and of the coefficient of reaction e, the value of which has to be ascertained experimentally. In the HÜTTE Manual, e is given the value 5/9, which can be accepted provisionally. This coefficient has a minimum value depending on the conditions of the problem.

The first condition for hunting to occur is that the point A must leave the rail after the shock; for this to take place:

$$u + \omega\ c > v.$$

If we substitute in this equation the value u given by formula (9), we obtain :

$$\frac{1 + e}{1 + e} > 3 \quad \text{or} \quad e > 0.5 \qquad (13)$$

The second condition e must satisfy is deduced from the maximum deviation of the vehicle. This will be given by

$$\sigma < \frac{2}{3}\frac{\varepsilon}{c} \quad \text{or} \quad \alpha < \frac{\varepsilon}{c} \qquad (14)$$

To ascertain the value of α resulting from the data of the problem, we begin by drawing in (fig. 2) the almost circular trajectory (translation and rotation approximately uniform) of the centre of the vehicle. The direction of the tangents to this trajectory at the points corresponding to two shocks of the tyre flanges is deduced from the triangles of speeds for the instant immediately before and after the shocks (figs. 3 and 4). As we know, before the shock occurs, the speeds u and v at right angles to the track add together, and the sum $u + v = u + V\,\alpha$, which takes into account the speed of translation of the vehicle, gives the resultant speed of translation of the centre of the vehicle at the instant considered, when its inclination to the centre line of the track is given by the angle $\alpha + \beta$ (lines AB and DE of figure 2). We conclude from this that

$$u = V\,(\alpha + \beta) - V\alpha \quad \text{or} \quad \beta = \frac{u}{V}\,.$$

The angle β is formed by the tangent of the trajectory of the centre of the vehicle with the center line of the latter prior to the shock occurring.

After the shock (fig. 4), the reflected speed of the centre of the vehicle is as we know u; this speed is subtracted from $v = V\,\alpha$; the resultant being now inclined at the angle α β and β retaining its former value or u/V. In figure 2, the directions of the resultant speed, that is to say of the tangent to the path of the centre after the shock, are AC and DE, marking on this figure the angles that the trajectory of the centre of the vehicle

resulting from the shocks at the wheel flanges shows at the points A and D.

Figure 2 enables us to calculate the approximate values of the length of the longitudinal oscillation D and of the transverse oscillation of the centre of the vehicle 2 ε' as follows :

$$D \sim 4\,R\,\alpha \qquad 2\,\varepsilon' \sim \frac{D\beta}{2}.$$
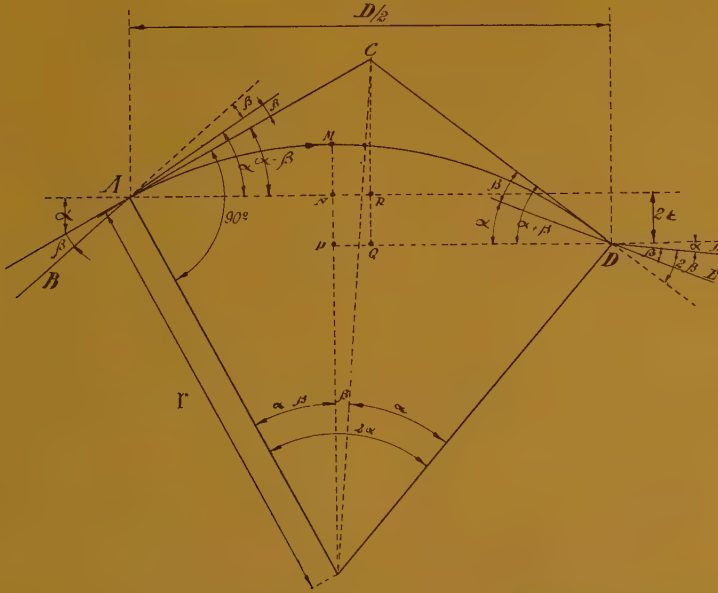
Fig. 2.

From figure 2

$$2\,\varepsilon' = MP - MN \sim \frac{[2\,r\,(\alpha + \beta)]^2}{8\,R} -$$

$$- \frac{[2\,r\,(\alpha - \beta)]^2}{8\,R} \sim 2\,r\,\alpha\beta \sim \frac{D\beta}{2}.$$

Knowing 2 ε', we can deduce 2 ε by the equation

$$2\,\varepsilon = 2\,\varepsilon' + \omega\,c\,\frac{T}{2} = 2\,\varepsilon' + 2\,\alpha\,c$$

as the movement of the tyre flange at right angles to the track is the sum of the translation movement of the centre of the vehicle and of the movement of rotation of this centre in the average period.

Substituting, in this equation, for 2 ε'

its value $\dfrac{D}{2}\,\beta$, and replacing β by

$$\beta = \frac{u}{V} = \frac{\omega d - \dfrac{v}{2}}{V}$$

[deduced from equation (6)], and at the same time taking into account that D = VT,

$$c + d = c\,(1 + K)$$

$$\text{and } D = \frac{8c\,(1+K)\,(1-e)}{1+e} \qquad (12)$$

$$\text{whence } \alpha = \frac{\varepsilon\,(1 + e)}{2\,ce\,(1 + K)} \qquad (14$$

For $\alpha < \dfrac{\varepsilon}{c}$,

$$\frac{2\,(1+K)\,e}{1+e} > 1 \text{ or } e > \frac{1}{1+2\,K} \qquad (15)$$

Fig. 3.

Fig. 4.
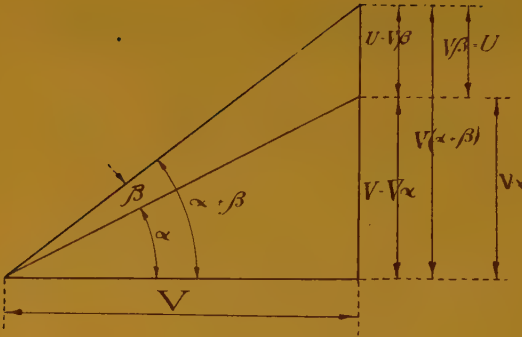
As **K** is generally > 1, equation (15) requires that $e \gg 1/3$, and so gives a lower value than the minimum required by formula (13).

The value $e = \dfrac{5}{9}$ in this way satisfies the conditions of the problem and can be adopted.

Equation 12 then gives us

$$D = 2\,c \times \frac{8}{7}\,(1 + K) \qquad (16).$$

Remarks on formula (16).

The above investigation differs from the real facts in that the opposing resistance due to friction has been ignored. The results given by formula (16) will not agree with those obtained experimentally and the difference will be the greater as the energy brought into play by the shocks become less, or as, at equal speed, the moment of inertia of the vehicle considered is smaller.

We can expect the values given by the formula in question to be smaller than the actual values, as the resistance must result in a reduction in the transverse speed and the angular speed, and therefore in an increase in the period of oscillation and the value of D. We also think the formula cannot be applied in cases
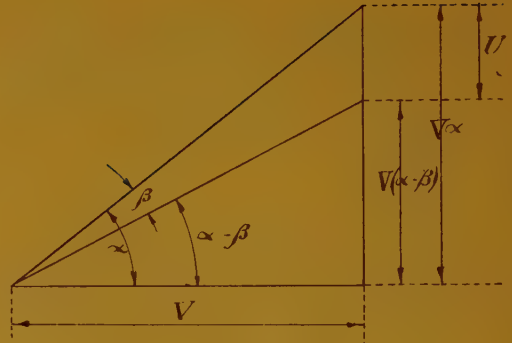
when the speed is such that : $\dfrac{V^2}{R} > f\,g$ (in which f is the coefficient of friction between rail and wheel), because the friction is then insufficient to keep the vehicle in its circular trajectory. To calculate R, let us make $R = \dfrac{D}{4\alpha}$. If we take into account the formulæ (12) and (14), and make $e = 5/9$ we shall get

$$R = \frac{\overline{2\,c^2}}{2\,\epsilon}\;\frac{(1 + K)^2}{4.9} \qquad (17)$$

The above condition thus becomes :

$$V < 2\,c\,(1 + K)\,\sqrt{\frac{f\,g}{2\,\epsilon \times 4.9}} \qquad (18)$$

Applications.

Let us examine, to begin with, the case of a passenger carriage bogie. In this case formula (3) gives $D = 30$ m. (98 ft. 5 1/8 in.), whereas in practice $D = 25$ m. (82 ft. 1/4 in.). Formula (16) gives (for $K = 1$), $D = 5.70$ (18 ft. 8 7/16 in.), a value much lower than the real one. The difference can be attributed to the preponderant influence of the tapering of the tyres on the energy of the shock, which in this case is small, considering that the moment of inertia of

the bogie is also small; there would appear to be another cause of this, in view of the great difference observed. Let us see if formula (16) is applicable to this case. The limit of speed given by the equation (18) will be when $f = 0.20$ and $2 \varepsilon = 0.02$,

V < 7 m. (22.965 feet) per second or < 25 km. (15.5 miles) an hour, that is to say in practice formula (16) is not applicable, which explains why it gives results which cannot be accepted.

Let us now consider the case of an old design of four-wheeled vehicle with $2 c = 3.60$ (11.81 feet) and K = 1.4 (4.59 feet). Formula (16) gives D $\sim$ 10 m. (32.81 feet) and formula (18) for $2c = 0.03$, V < 32 or 115 km. (71.46 miles) an hour. The equation (16) therefore can be applied, this speed being high for the old stock. If formula (3) be applied to this case we get D = 52 (170.6 feet); practice give D $\sim$ 14 m. (45.930 feet), a value much nearer that of formula (16) than of formula (3), which is explained by the fact in this case that the reactions due to the shock are much higher; the value given by (16) is less than that obtained experimentally as we expected.

In a tramcar we have found D $\sim$ 7 (22.965 feet). Formula (16) gives for $2c = 1.8$ (5.905 feet) and K = 2, D = 6.50 (21.326 feet); formula (3) would give a much higher value than the actual one. In the case of a bogie electric motor coach, the observed value D $\sim$ 5 m. (16.404 feet); the calculated value from (16) is for $2c = 2$ (6.561 feet) and K = 1, D = 4.60 (15.092 feet). The value given by formula (3) is too high.

In the cases considered, the equation (16) gives values lower than the true ones, and equation (3) higher values; the latter gives incorrect values, when the moment of inertia of the vehicle is high and formula (16) we have established is

the only one applicable in this latter case within the limits given by equation (18).

Besides ignoring the resistance due to friction the vehicle has been taken as completely rigid and indeformable, whereas in fact it is subjected not only to elastic deformation, but to other forces such as those due to the play in the bearings and in the axle guards. The effect of the buffing and draw gear has also been ignored. These factors further reduce the shock which, as we have said, seems exaggerated in this simplified investigation.

As a practical conclusion to our study and within the limits of approximation permitted thereby, we can recommend limiting the play in the track and increasing the wheel base of the vehicles; this reduces ε — formula (14) — which in turn lessens the violence of the impact against the track; it also increases D (16), which means fewer shocks. At the present time, there is a tendency to reduce the play and this also lessens the shocks when entering curves. As regards the wheel base, in Germany that of passenger vehicle bogies has been increased from 2.50 m. (8 ft. 2 7/16 in.) to 3.60 m. (11 ft. 9 3/4 in.) with good results. Reduced track clearance, moreover, has been recommended in conclusions of the Railway Congress. We think these two points should draw attention in Spain where, in our opinion, the rolling stock is given too much play and where the bogie wheel base is 2.50 m. (8 ft. 2 7/16 in.). We think this should be 3 m. (9 ft. 10 1/8 in.), a value less than the German, in view of the more frequent curves of small radius in Spain.

* * *

Bibliography.

The books and papers mentioned in the text are :

MARIÉ : « Oscillations de lacet des véhicules

‹de chemins de fer » (Hunting of railway rolling stock).

POCHET : « Théorie du mouvement en courbe sur les chemins de fer » (Theory of the motion on railway curves) (pages 185 et seq.).

CARTER : « Railway Electric Traction » (pages 69 and 72).

LEBOUCHER : « Revue générale d'électricité » ·(14th December, 1918).

M. MAUZIN : « Etude sur le lacet des véhicules » (Investigation into the hunting of vehicles) *Revue Générale des chemins de fer*, January 1933, page 25.

M. BLONDEL : « La résistance de la voie aux oscillations de lacet des véhicules » (The resistance of the track to the hunting of vehicles) *Revue Générale des chemins de fer*, December 1932, page 439.

[**621 .43**]

Transmissions for Diesel locomotives and railcars.

Recent developments in Vulcan-Sinclair couplings for traction applications,

by STUART MIALL, B. Sc.

(Diesel Railway Traction, Supplement to *The Railway Gazette.)*

Four years have elapsed since the Vulcan-Sinclair hydraulic coupling first made its appearance in the automobile world under the name fluid flywheel, and already some 20 000 vehicles are driven through a fluid medium. Early in 1932, *The Railway Gazette* announced that this coupling had been made more suitable for traction purposes than the original fluid flywheel by the addition of a reservoir chamber on the back of the runner or driven member, with the object that the coupling gives an easier start from rest and has considerably less slip at normal running speeds.

The new development, known as the Vulcan-Sinclair traction coupling, has been very widely applied to railway and road haulage, and within recent months it has been still further developed to extend its sphere of usefulness for locomotive and railcar, and also to crane and winch applications.

Limitations of fluid flywheel.

In this article the new modifications will be described. First of all, however, the limitations of the fluid flywheel and the plain traction coupling will be indicated. The chief disadvantage of the ordinary fluid flywheel is that unless it be designed to have a relatively high slip under full speed full load conditions it will transmit a very considerable drag torque at idling speeds of the engine. The commercial fluid flywheel represents a compromise, the efficiency of drive being as high as is consistent with a manageable drag torque, but not so high as could be desired. The traction coupling gives a lower drag torque than the ordinary fluid flywheel in the stalled condition, and yet has a much lower slip at normal vehicle speeds, *i. e.*, a higher all-round working efficiency. This is due to the action of the internal reservoir, which under starting conditions partly empties the working circuit formed by the impeller and runner, thus reducing the drag torque. As the vehicle accelerates, the liquid is automatically returned to the working circuit under centrifugal pressure, so that the operation is that of a completely filled low slip coupling of very high efficiency. Under starting conditions the partly-filled working circuit of the coupling is

capable of transmitting full engine torque at relatively high engine speeds, but the drag torque it can transmit from an idling engine is much less than the drag
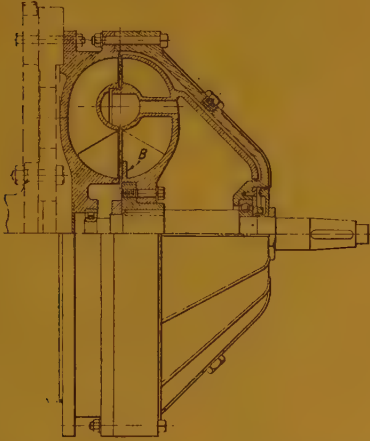
Fig. 1. — Arrangement of Vulcan-Sinclair traction-type coupling with anti-drag baffle.

of a full coupling under similar conditions. The parly-filled coupling with its runner stalled puts less restraint on the engine than a full coupling when acceleration from idling takes place, but with

its impeller run up towards the speed at which the engine will deliver its maximum torque the partly-filled coupling will readily transmit that torque. Consequently, the runner is started without difficulty against the load which is thus set in motion. As the runner speed increases, the centrifugal tendency of the oil in the reservoir chamber also increases, and at a given speed this pressure is such that the oil is transferred back into the working circuit of the coupling. The efficiency of operation is high beyond this point, the slip at full power falling ultimately to below 2 %.

The volume of liquid supplied with the coupling is such that the working circuit is filled before the reservoir is emptied; as a result the liquid in the working circuit is under sufficient centrifugal pressure to exclude all air, and at the same time it is free to expand when its temperature is increased. The reservoir acts as an air-separating chamber so that the working circuit is kept full of the hydraulic operating medium, while the air collects in the centre of the reservoir.

In the simple fluid flywheel the absence of an expansion chamber is a distinct drawback, since the working cir-
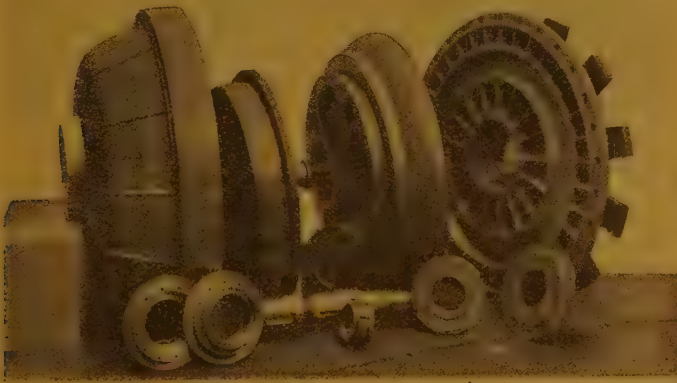
Components of Vulcan-Sinclair ring-type fluid coupling showing relation of ring-valve to runner.

cuit must contain a mixture of oil and air, which naturally reduces the efficiency. If the working circuit be completely filled with liquid, with no air space for expansion, and if the glands be tight, then a material increase of temperature will result in the bursting of the fluid flywheel casing.

The starting characteristic of the traction coupling can be readily altered to suit any particular diesel engine; e. g., by varying the size of the internal reservoir chamber. Hence with a small reservoir chamber the working circuit is only partially emptied of liquid under the stalled condition, whereas with a large reservoir the quantity of liquid transferred from the working circuit when starting is greater, and hence an easier start is given without impairing the low value of slip at normal running speeds. It is also easy to adjust the characteristic by varying the quantity of liquid with which the coupling is initially filled, until a limiting point is reached when there is just sufficient liquid to

fill the working circuit completely. This feature proves useful in connection with diesel locomotives where it is often found inadvisable in practice to run the engine at the minimum idling speed which it is possible to obtain under test-bed conditions. If the engine must be set to idle rather fast, it naturally follows that the drag torque with the runner stalled can be substantial in amount, and in consequence extra work is thrown upon the rocking brake when engaging and changing gear.

Traction coupling with anti-drag baffle.

If a case arises where the stable idling speed of the engine is inconveniently high, and length limitations do not permit the use of a specially large reservoir, an alternative method has been evolved, namely, to modify the hydraulic circuit of the coupling by fitting an annular baffle plate B to the runner. This is shown by figure 1 in relation to a normal Vulcan-Sinclair traction coupling.
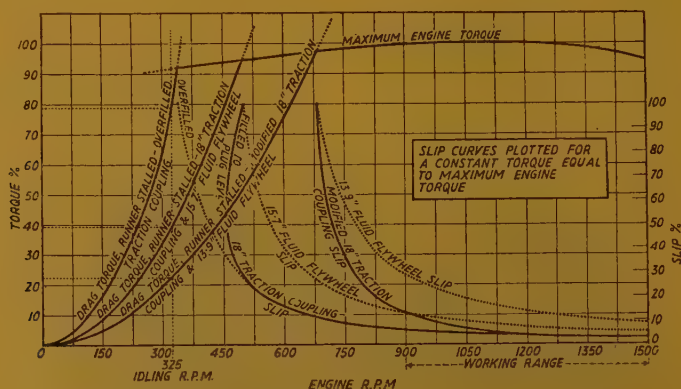
Fig. 2. — Characteristics of Vulcan-Sinclair traction-type coupling with anti-drag baffle with different operating conditions and sizes.

When the impeller and runner are rotating normally at speeds of the order of 1 000 to 1 500 r. p. m. the slip is low and the baffle makes little or no difference to the performance of the coupling,

as the centrifugal tendency of the liquid in the coupling causes the vortex ring to flatten somewhat on its inner periphery and to run clear of the projecting baffle plate. Furthermore, the rate at

which the vortex ring turns « outside in » and « inside out » is comparatively low, so that if penetration of the ring by the baffle plate does take place the eddying which results will be inconsiderable. The influence of the baffle becomes important when the speed of the engine is diminished and when in consequence the runner speed falls below the limit where liquid is transferred to the reservoir. The reduced body of liquid tends to form a vortex of the largest cross section permitted by the configuration of the vaned members and to turn outside in and inside out at a high rate. Obviously the baffle must very effectively prevent the formation of any such vortex. Acting as an obstruction, it causes the motion of the fluid to become chaotic and in this way it diminishes the effectiveness of the coupling as a

transmitter of torque. The drag torque of the stalled traction coupling is reduced by about 50 % when this baffle is added, and the reduction is of great practical significance if the coupling is to be used with an engine which must be set to run at a somewhat high idling speed. Where a baffle is fitted the engine must be run up to a higher speed to start the runner against any given load. This is an advantage if the engine happens to be one which does not pull really well until turning at 600 to 700 r. p. m. Considered then as an adjunct to a diesel engine rather below the average in flexibility, the baffle-type traction coupling is an advance on the ordinary traction coupling and a still greater advance on the fluid flywheel.

Its characteristics are shown by figure 2, in which, for purposes of com-

General view of the components of the latest type of Vulcan-Sinclair traction-type fluid coupling with anti-drag baffle.

parison, curves relating to an unmodified traction coupling also of 18-inch size and to fluid flywheels of 15.7-inch and 13.9-inch profile diameter are also shown. It is striking that the slip of the baffle-type coupling is no higher than the ordinary traction coupling at the high speed end of the range.

Caracteristics of traction coupling with anti-drag baffle.

An overfilled traction coupling is virtually a fluid flywheel designed to give a low slip under normal operating conditions and a very heavy drag torque. In figure 2 the lowest slip curve and the

highest drag torque curve relate to an overfilled 18-inch traction coupling. The same coupling filled to the correct level gives no greater slip over the normal working speed range, but if the impeller speed be reduced below 520 r. p. m., the torque meanwhile being kept constant at its full value, the liquid begins to leave the working circuit, and with a further small decrease of engine speed the slip becomes 100 %. As can be seen from the middle drag torque curve, the torque that the coupling exerts at a low impeller speed with its runner stalled is little more than half the corresponding figure for the overfilled coupling, *i. e.*, for the equivalent fluid flywheel. The dotted slip curve labelled « 15.7-inch fluid flywheel slip » is for a fluid flywheel giving the same drag torque. It shows that the slip under normal working conditions of such a flywheel must be about double the slip of the traction coupling giving the same drag torque. Putting a baffle into the 18-inch traction coupling almost halves the drag torque again, and as can be seen from the slip curve, the baffle does not observably change the action of the coupling under full torque until the impeller speed falls below 1 200 r. p. m. The highest slip curve is for a 13.9-inch fluid flywheel giving the same drag torque as the modified 18-inch

traction coupling. Again it is seen that for a low drag torque the fluid flywheel must be designed to give an excessive amount of slip.

The ring-valve traction coupling.

In point of time the forerunner of the baffle type coupling is a coupling having
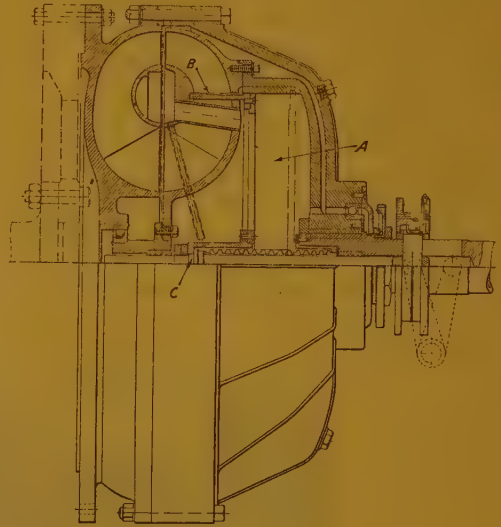
Fig. 3. — General arrangement of Vulcan-Sinclair fluid coupling of the ring-valve traction type.
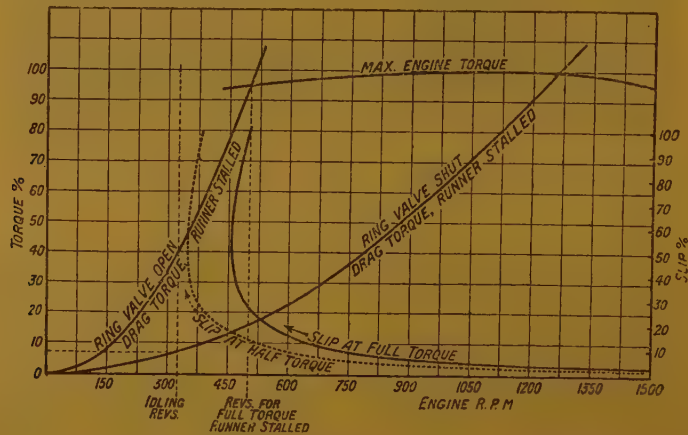
Fig. 4. — Characteristics of Vulcan-Sinclair ring-valve type traction fluid coupling.

the baffle movable instead of fixed. Figure 3 shows a coupling of the traction type with a reservoir at A and having a movable baffle B, called a ring valve, in addition. This coupling combines the advantages of the traction coupling and of the ring-valve type. The baffle in this instance can be moved so as to be a complete barrier to normal fluid circulation, but its position is such that when partly closed it does not have the same dual effect as has been described for the fixed baffle in the traction coupling. Only by virtue of eddies and skin friction does the ring-valve coupling with the ring valve shut manage to exert a drag torque. Figure 4 shows that the drag torque due to these effects is only about one-sixth of the drag torque given by the same coupling functionning as a normal traction coupling with the ring valve open. By moving the ring valve to an intermediate position the slip can be regulated to suit the requirements of load and speed, but owing to the existence of a channel over the outer periphery of the ring valve into the reservoir chamber, the liquid passes out of the working circuit more readily than in the traction coupling having no ring valve.

Ring-valve couplings were made several years ago, and are in use in different parts of the world, but the coupling shown in figure 3 and in other illustrations is in many respects an advance on the older type. Besides possessing all the special features of the traction coupling it is a great improvement mechanically. The ring valve and its push rod form a single moving part in the new coupling, whereas in the older coupling there were four push rods and four operating levers. In the new coupling a flexible bronze bellows, bronze welded to the push rod C, makes oil leakage a physical impossibility, whereas in the older coupling four stuffing boxes were used. In the new coupling the ring valve forms part of the runner assembly and is immune from engine vibrations, whereas in the older coupling it formed part of the impeller assembly. The older coupling continues to give satisfactory service, but the new coupling, though cheaper to construct, seems likely to have an even better record in view of the almost complete absence of wearing parts and the total absence of leather or other packings.

The ring valve, which is actuated by the usual fork and collar mechanism, affords a useful means of control where loads have to be started against excessive static friction. With the ring valve closed it is still possible to transmit a large proportion of the maximum torque through skin friction and eddies if the engine speed is increased sufficiently. By then withdrawing the ring valve the full circulation of the fluid is established so that the torque transmitted can be raised to several times the maximum value without causing any shock to the engine or transmission. The time during which such a torque can be sustained will, of course, be limited by the inertia of the engine flywheel, but in starting a heavy train the pull required to overcome static friction need only be momentary. The new ring-valve coupling has proved useful in industrial applications, and it has been found to facilitate the control of the load on cranes and hoists, as here again static friction plays an important part.

Thus, when the maximum load is picked up with a little slack in the rope, the engine torque may be easily sufficient to sustain it in motion. On the other hand when starting a suspended load from rest, the static friction of the train of gears may be so high that the engine torque is insufficient to hoist the load. By using the ring-valve type of coupling it is possible to obtain a momentary overload torque, as described above, to set the load quickly in motion.

Mechanical transmissions for railcars.

Swiss oil-operated system has given satisfactory results over a number of years, and has recently been applied to French vehicles.

The service and running conditions of diesel railcars demand qualities in design not found in a locomotive. They must combine lightness with rigidity in construction and flexibility in operation, and they must possess high rates of acceleration and retardation, low first cost and maintenance charges, and simplicity of handling. Experience in various parts of the world has indicated that with such vehicles mechanical transmission in the majority of cases gives satisfactory results, especially where efficient clutch and gear-changing devices are available.

A type of transmission which has

Fig. 1. — Mechanical transmission with SLM-Winterthur fluid clutches as used on 185-B.H.P. railcar.

shown reliable service over a number of years is the SLM-Winterthur oil-operated gear made by the Swiss Locomotive & Machine Works, and the British patents for which are held by Modern Wheel Drive Limited, of 18, Victoria Street, London, S. W. 1. This system was originally evolved about 10 years ago. It has been in operation for more than eight years on locomotives and railcars in Europe and five in Siam, and has more recently been applied to a number of railcars in France, including the De-cauville car on the Nord, and the Acié-ries du Nord car on the Paris-Orléans. Further cars of the latter type, but with 300-B.H.P. engines, have been delivered to the State and ordered by the Paris-Orléans Railway.

The essential part of the SLM-Winterthur transmission is the change-speed gear with couplings operated by oil under pressure. The number of speeds varies according to the conditions imposed by the service, but normally there are four or five. The gearwheels of all

Fig. 2. — Assembly of 185-B.H.P. diesel engine and mechanical transmission fitted with SLM-Winterthur oil-operated clutches.

steps are constantly in mesh. With this change-speed gear the main coupling is unnecessary, as each speed has its own coupling, or clutch, located within the large toothed wheels on the secondary shaft. An examination of figure 3 shows that the coupling consists of two exterior discs with concentric grooves which form a hollow toothed wheel, and which, when disengaged, turn loose on the hubs of the interior discs, or clutch plates. The latter, with identical concentric grooves, can move axially on the secondary shaft, which is provided with longitudinal splines. It is a three-step change-speed gear which is shown in figure 3, and two of the couplings are shown in section, one engaged and the other disengaged.

The engagement of any speed is effected by a distributing cock which directs the oil under pressure between the interior faces of the toothed discs. The cock is so arranged that while one coupling is being engaged all the other steps are automatically disengaged. The primary shaft of the gearbox is connected to the engine, whereas the secondary
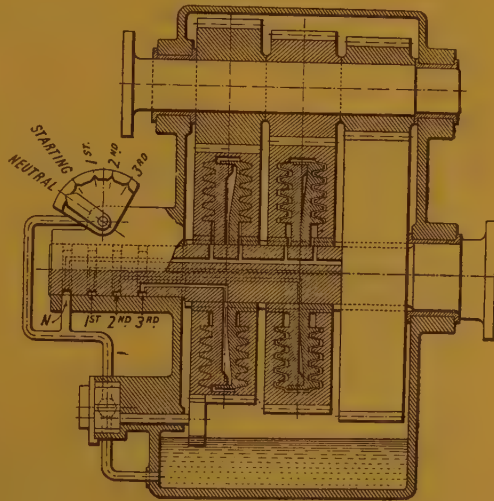
Fig. 3. — Diagrammatic arrangement of SLM-Winterthur oil-operated clutch.

shaft is generally coupled to the reversing gear, which has couplings of the dog clutch type operated by a lever or by compressed air.

IV—8

The use of horizontal cardan shafts connecting the reversing gear to the driving axles, and the avoidance of all angular leads is an important advantage of the normal design, for the gearbox is so arranged that the difference in height between the engine shaft and the axles is absorbed by the normal centre distances of the gear shafts. The axle drive usually consists of a simple set of bevel gears. As a rule, the entire engine-transmission combination is mounted directly on the bogie.

The transmission for a diesel engine developing 185 B.H.P at 1 000 r.p.m., as shown in figure 1, weighs only 5 960 lb. including the driving axles. All parts are of rigid construction and the brackets on which the change-speed and reversing gear are suspended in the bogie are of substantial design, and serve also as cross-stretchers for the bogie frames. A similar unit for a high-speed railcar with an engine developing 300 B.H.P. at 1 500 r.p.m. weighs only 6 620 lb., including the suspension brackets, which also act as cross-stretchers and carry certain parts of the brake rigging.

Starting, speed-change and acceleration.

Smooth and shockless starting is effected by the admission of oil at below full pressure. The three positions of the switch cock correspond to :

a) Neutral position. All couplings disengaged;

b) Starting position. The coupling of the first speed under oil at reduced pressure;

c) Position for first speed. The coupling of the first speed is under oil at full pressure.

By moving the switch cock handle further round its sector three more positions are gained, and in each of these the oil under pressure is directed to the clutches of the corresponding speeds. The change from one speed to another

is carried out solely by turning this cock, and the transition is almost immediate.
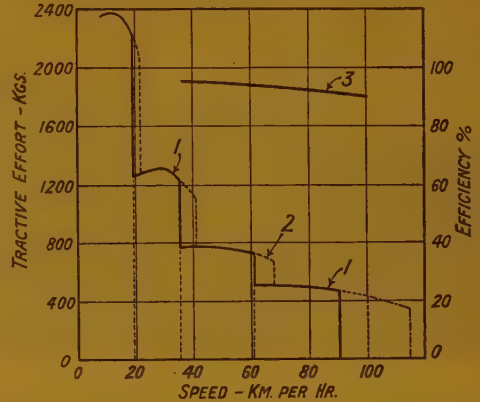
Curve 1. — Tractive effort with normal engine revs.
Curve 2. — Tractive effort with 10 % higher speed.
Curve 3. — Efficiency of mechanical transmission.

Fig. 4. — Characteristics of 185-B.H.P. mechanical transmission.

The relations between the tractive effort, speed, and transmission efficiency of the installation shown in figure 1 are indicated in figure 4. By reason of the high efficiency, and notwithstanding the tractive effort steps, accelerative values are obtained which equal those given by certain electric transmissions, and at high speeds even exceed them. The curves A and B in figure 5 give the
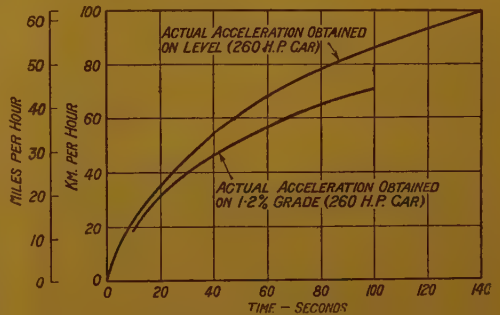
Fig. 5. — Acceleration curves of 260-B.H.P. diesel-mechanical railcar.

speed-time values obtained on the level and on a grade of 1.2 % (1 in 83) with a car weight of 37.5 tonnes. Reading from curve A it is seen that a speed of 100 km. (62 miles) per hour is reached in 140 seconds when on the level.

Operating mechanism.

Gearboxes of the type just described can be operated by any system of mechanical, pneumatic, or electro-pneumatic control capable of transmitting or supplying the trifling effort required for turning the distributing cock. There is no difficulty in providing a railcar with two gear-boxes and two driving bogies to operate simultaneously. Slight temporary differences in the synchronisation of the two engines are readily absorbed by the couplings, and an absolute synchronism of the two power sets is not essential. The reversing gear, which as a rule is of the mechanical type with dog clutch couplings, is normally operated by compressed air. The equipment of the driver's stand, or stands, is consequently reduced to one lever for the operation of the gearbox and a second lever for the reversing gear.

Safety devices.

The SLM-Winterthur transmission is suitable for use in conjunction with
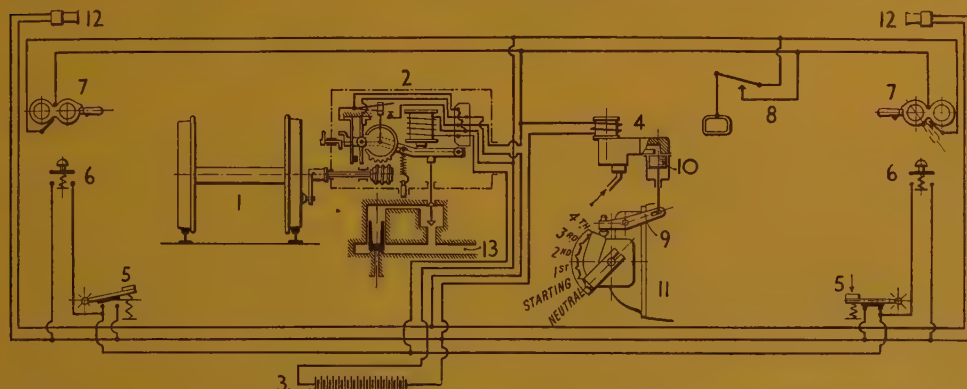
1. Wheel and axle. — 2. Brown-Boveri safety apparatus. — 3. Battery. — 4. Electro-pneumatic valve. — 5. Dead-man pedal. — 6. Dead-man handle. — 7. Driver's brake valve. — 8. Emergency handle. — 9. Starting cock lever. — 10. Piston. — 11. Control cock. — 12. Alarm signal. — 13. Air brake system.

Fig. 6. — Diagram showing operation of safety device with mechanical transmission.

various safety devices such as free wheels, dead-man handles, automatic train control, emergency engine governors, and automatic disengaging appliances for emergency braking.

In figure 6 is shown the operation of a dead-man handle attachment consisting of a combined disengaging arrangement and Brown-Boveri safety apparatus. Release of the pressure on the driver's foot-pedal 5, causes the safety appliance 2 to function, and after a run of about 90 to 100 yards this excites the coil of the electro-pneumatic valve 4.
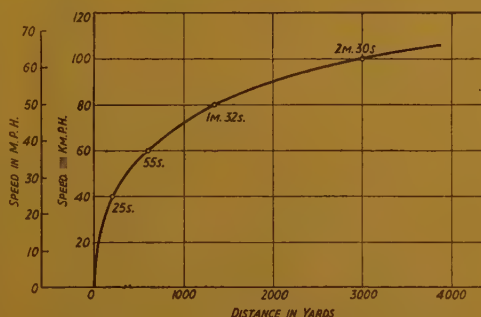
Fig. 7. — Acceleration curve of 300-B.H.P. diesel-mechanical railcar.

Under the action of the piston 10, the lever 9 of the starting cock is at that moment moved to the free running position, thus causing the automatic disengagement of the gearbox drive. At the same time the air brake comes into action. It will be seen from the illustration that the coil of the electro-pneumatic valve can be excited, and the instantaneous disengagement obtained, by pulling the emergency handle 8, or by making an emergency application of the brake by means of the driver's brake handle 7. The emergency governor, to prevent overspeed of the engine, and the automatic train control apparatus operate the safety appliance in a similar manner, but for the sake of simplicity are not indicated.

[621. 43]

Direct-drive diesel locomotives,

By G. DELANGHE

Ingénieur des Arts et Manufactures,

Chef de travaux, Ecole Nationale supérieure de l'Aéronautique (France).

(Le Génie Civil.)

The article in the *Génie Civil* of the 31st December 1932 ([1]) on the applications of the diesel engine to railway traction, summarising the paper we gave at the 1931 Civil Engineering Congress, was written with a view to bringing out the economic value of the diesel engine in railway working and dealt with the principal aspects of the problem.

The steam locomotive which may be taken as our model, develops a torque which increases as the speed decreases, at least within the limit of adhesion. On the other hand, the diesel engine gives, for a given admission of fuel, a torque which is almost constant. For this engine to be suitable for railway traction, its torque must reproduce as closely as possible that of the steam locomotive, this being obtained by introducing, between the engine and the wheels, a transmission (electric, mechanical, hydraulic or pneumatic), or by changing the characteristics of the engine (in particular, by supercharging).

In concluding the above mentioned article, we underlined the attractiveness of the direct drive, supercharging being mentioned as one of the simplest ways by which the direct drive could be obtained. In this connection, it will be remembered that the first diesel locomotive put into service was fitted with a direct drive. This locomotive was the 2-B-2 (4-4-4) supplied by Sulzer Brothers to the *Prussian State* Railways. The engine was a reversible, two-stroke, 4-cylinder 380 × 550 mm. (14 15/16 in. × 21 11/16 in.) 90° V engine developing nominally 1 000 H.P. The crank shaft was directly coupled to the wheels. Compressed air supplied by a compressor driven by a 250-H.P. auxiliary diesel engine was used to start up the main engine, and at the same time the train. At about 15 km. (9.3 miles) an hour, the main engine began to fire, but was assisted by means of compressed air until the speed exceeded 25 km. (15.5 miles) an hour. When the engine was running at 304 r. p. m., the speed of the locomo-

---

(1) See also *Bulletin of the Railway Congress* for June 1933, page 559.

tive reached 100 km. (62 miles) an hour. After being run in on the Winterthur to Romanshorn line, the engine was sent under its own power to Berlin via Basle and Strasbourg (1 100 km. = 683.5 miles).

Tests were then made on the Berlin-Mansfeld line. One of the chief difficulties experienced was the intense cooling down at each start, by the expansion of the compressed air in the main cylinders : the effect was that the engine would not fire properly until it was running at a much higher speed than would have been necessary had it been working as an ordinary diesel.

Supercharging can be arranged in three ways :

1. At the end of the admission period, or at the beginning of the compression period, air supplied by a compressor at on overpressure of a few hundred grammes per square centimetre, and the quantity of which can be regulated, is forced into the cylinder; the weight of air in the cylinder is thereby increased as compared with the weight drawn in on the suction stroke from the atmosphere. This is supercharging in the proper sense of the word.

2. At the end of the compression period, air under high pressure, and the quantity of which can be regulated (its pressure must, of course, exceed that in the cylinder) is introduced into the cylinder. The weight of air in the cylinder is again increased but by a process we will distinguish from the former by calling it « pressure charging ».

3. The compression is effected in a separate motor-driven compressor; the compressed air so produced is introduced into the engine cylinders at the start of the exhaust stroke. This is the separate compression method.

Supercharging proper has already been dealt with in the *Génie Civil* and especially in the 15th February 1930 number, so need not be gone into here. The figures obtained from a number of

investigations show that, far from overstraining the injection engine, the thermal stresses are reduced and further, by the better diagram obtained, the crank axle and connecting rod ends work under much more favourable conditions than where supercharging is not used. The conclusions on the effects of supercharging on the mechanical behaviour of the engine are often wrong, because the change in the diagram near the combustion zone is not taken into account. We must, therefore, expect the use of supercharging with diesel engines to be widely adopted in future, and to exercise a most important effect on the development of this type of engine.

We propose to examine here how the two processes of pressure charging and separate compression may help to solve the direct-drive problem.

Pressure charging.

This process has been used recently by Messrs. Deutz during the starting period on a direct-drive diesel locomotive. The following particulars of the trials made whilst developing this method are taken from the article published by A. Langen in the *Forschungsheft*, No. 363 [1], headed « The direct-drive diesel locomotive ».

Preliminary tests of a pressure-charged engine. — The first tests consisted of trials of different methods of pressure charging carried out on a four-stroke vertical stationary engine with cylinders 250-mm. (9 27/32 in.) bore and 450-mm. (17 11/16 in.) stroke, with mechanical injection, developing 50 H.P. per cylinder at 300 r. p. m.

As the power of this engine was almost constant above 75 r. p. m., endeavours were made to pressure charge it by means of a compressor in such a

(1) *V. D. I.* publications, Berlin N. W. 7. — A pamphlet of 22 pages dated November-December, 1933.

way as to keep the power more or less constant between 75 and 150 r. p. m. The air was introduced into the cylinders by a balanced valve at the beginning of the exhaust stroke. Taking advantage from the turbulence set up when the compressed air entered the cylinder, it was possible to maintain good combustion whilst varying the quantity of oil injected in proportion to the volume of air admitted. No increase in temperature fatigue was noted but the compressor designed to supply a volume of air equal to that normally drawn in by the motor at 75 r. p. m. absorbed 22 H.P., obviously a prohibitive figure.

Starting under load trials. — Tests were made to start using air at 60 atm. (853 lb. per sq. inch) pressure. The expansion of this air in the cylinder cooled it down so much that the engine would not fire below 60 r. p m. The equipment for compressing and storing the air was unreasonably cumbersome.

To overcome the cooling due to expansion, an attempt was made to heat the compressed air before admitting it to the cylinder.

As a surface heater was impracticable owing to lack of space, part of the oxygen from the supercharger was used to burn a continuous additional supply or fuel oil. Very little oxygen was required to heat the air to 500° C. (932° F.). When starting up, however, the admission gear, the heat capacity of which is considerable, cooled down the heated air and caused the water vapour to condense. This difficulty was overcome by heating the compressed air in the cylinder of the engine, by burning a small quantity of fuel oil in it. The compressed air is supplied to the cylinders as before at the beginning of the exhaust stroke.

The power required to start the engine, and at the same time the train, is obtained not by means of compressed air alone, but also from the energy developed by the combustion immediately the air is supplied to the cylinder. The power taken by the compressor can be thus reduced in an appreciable manner. In order to preheat the air, the heavy oil must be properly pulverised and a reliable device for igniting it by incandescence must be kept alight. Electrically-heated spiral-wound plugs are not robust enough for the application in question, and through their low heat-retaining capacity they are subject to very great temperature variation during each single cycle. After testing many types of plugs, especially those in which the incandescent element is a small stick of silicon carbide, the incandescent ele-
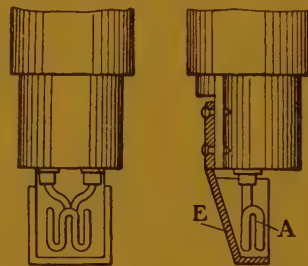
Figs. 1 and 2. — Plug with incandescent filament for igniting the jet of fuel oil.

ment selected as best was a filament A (fig. 2) in heat-resisting steel 3 mm. (1/8 inch) in diameter, protected by a steel shield E against the stream of cold air entering through the inlet valves. Each plug takes 100 to 120 watts at 1.5 to 2 volts.

In a multiple-cylinder engine, the plugs are in series with a small dynamo, the speed of which varies according to the number of plugs.

In order to investigate at the test bench the behaviour of the engine at starting, the motor was coupled by a belt to a shaft with heavy flywheels. The ratio of the radii of the pulleys driven by the belt was such that the driven shaft ran at a much higher speed than

the engine and so offered a greater starting resistance. The engine flywheel was fitted with an absorption brake. The air supply for starting was supplied at a constant pressure of 35 atm. (497 lb.
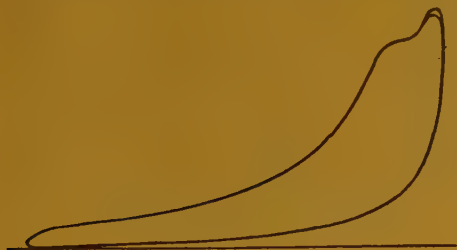

Fig. 3. — Starting diagram with compressed air and injection of fuel oil with forced ignition (angular speed 20 r. p. m.; average indicated mean pressure 10.8 kgr./cm² (153.6 lb. per sq. inch).

per sq. inch). During each test, the number of revolutions was kept constant, and the time the compressed air inlet valve was open and the quantity of heavy oil injected were adjusted until the best setting was obtained.

The tests showed that when the engine is hot, seven eights of the compressed air required to start when the air is not heated by partial combustion at admission can be saved. When the engine is quite cold, the saving is less, but still makes it possible to use a compressor group of reasonable size.

Tests with an altered locomotive with mechanical drive gear. — A locotractor of 20 t (19.7 Engl. tons) fitted with a four-cylinder 200 mm. × 200 mm. (7 7/8 in. × 7 7/8 in.) two-stroke engine developing 100 H.P. at 430 r. p. m. was used. The maximum speed was 15 km. (9.3 miles) per hour. The transmission between the engine wheels consisted of a friction clutch, hydraulically controlled, a four-speed gear box, and a jack shaft. A 10-H.P. compressor group was fitted with a spare bottle of 500 litres

(176 cu. feet) capacity. When starting, the clutch was not used but was left engaged. The cylinders fired at the first revolution and the comsumption of compressed air was reasonable. Firing, however, was irregular during starting and produced unpleasant shocks.

The irregularities in the turning moment during the start made themselves felt and were aggravated by play in the teeth of the transmission gears. To overcome these defects, the number of cylinders would have to be increased and the drive made as direct as possible.

However, the Deutz Company found, from various investigations, that the system in question would be difficult to apply to main-line locomotives on account of the room required. The only acceptable solution from this point of view seemed to be to follow the classic steam locomotive design and provide, parallel to the horizontal longitudinal centre line of the engine, double acting cylinders, the first of which would be coupled direct to the driving axles.

Against this, this solution had the disadvantage of limiting the number of motor sections and meant that the violent ignition of the charge referred to above had to be prevented, in order to ensure smooth starting.

The Deutz Company, whilst retaining the principle of separate firing during starting, had therefore to design a system of pressure charging and combustion under moderate pressure, but with a high degree of charging up to some 100° of rotation of the crank shaft, on the lines of a steam engine. The fuel is introduced, at the moment of starting, through a special injector giving very fine atomisation, but with a reduced penetration. The proportion between the charging air and the fuel injector is regulated at each moment in such a way that undesirable untimely extra-high pressures cannot occur. Experience has shown that good combustion is possible without too great excess air.

By using compressed air as a combustion agent immediately it is admitted to the cylinder, at the beginning of the exhaust stroke, a saving of 75 to 85 % is made as compared with starting with compressed air alone.

Starting takes place as follows : the driver sets the pressure-charging gear in the full open position, and opens the valve admitting compressed air into the engine until the engine starts moving. As soon as the wheels begin to turn, the starting fuel injector pumps operate and the pulverised fuel is ignited during the first revolution of the wheels. As the speed of the locomotive increases the driver lessens the amount of pressure charging and then brings into action the ordinary fuel injection pump (high pressure), and ultimately stops the starting fuel injection pumps. The engine cylinders are then working with the usual injection with a little pressure charging. When ordinary running conditions are attained, the cylinders work under the ordinary injection process.
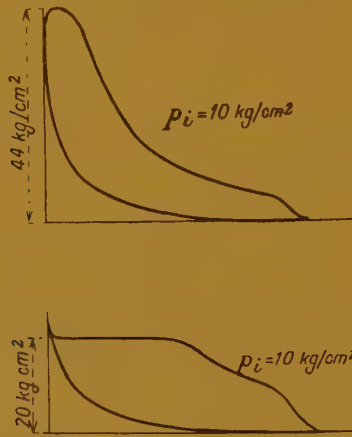
Fig. 4. — Indicator card and torque diagram when the air is introduced and combustion occurs under high pressure.
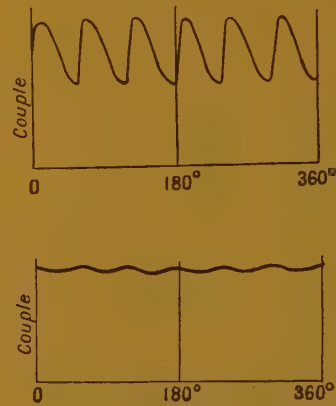
Fig. 5. — The equivalent card and diagram when the air is introduced and combustion takes place under medium pressure.

Figs. 4 and 5. — Curves showing the variation in torque in terms of the angle of rotation when starting with compressed air which is used as combustion agent at the same time.

Note : Couple = torque.

Figures 4 and 5 show the better turning moment obtained with this method of extending the pressure charging period with moderate pressure combustion than with the first method with its much higher pressures.

The two diagrams from which the turning moment curves were drawn were for the same mean indicated pressure, that is to say (for the same angular speed) the available power.

In order to try out their new processes and to develop a horizontal double-acting engine suitable for locomotive purposes, the Deutz Company built a two-stroke double acting single-cylinder engine. The piston is supported by a piston rod and a tail rod, the former coupled to the crosshead, at the rear end. At the front end the tail rod is running in a guide. The piston is water-cooled and, for constructional reasons, the wa-

ter is brought in at the trailing end of the cylinder. The scheme of bringing the water in through the tail rod by means of a plunger pump had to be abandoned, and a system of hinged pipes had to be developed instead. In order to overcome the violent shocks set up in the column of water through inertia effects at the 300 r. p. m. speed, the circulating water passages had to be improved and the quantity and pressure of the water delivered had to be raised.

The shape of the combustion chamber and the arrangement of the fuel injection nozzles required considerable develop-

gr./H.P./h.

Mean indicated pressure (kgr./cm²).
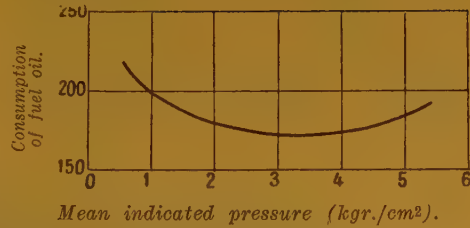
Fig. 6. — Curve of the specific consumption of the engine figure 7.

ment work. Figure 6 shows the variations in the specific consumption in terms of the mean effective pressure.
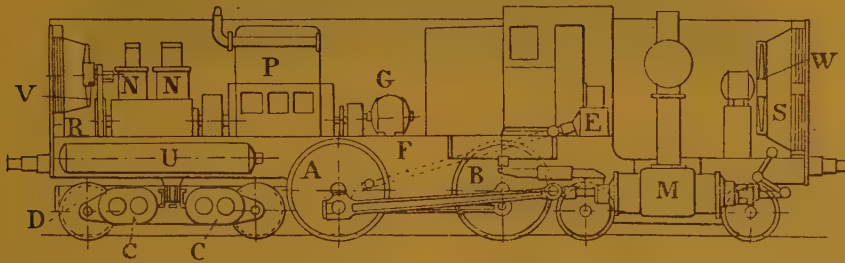
Fig. 7. — Diagrammatical elevation of Deutz diesel locomotive with direct drive.

The locomotive (figs. 7 and 8) built after this series of tests is intended to haul light express trains : it is a 2-B-2 (4-4-4) type engine with bogies at each end carrying 12 t. (11.8 Engl. tons) and two pairs of coupled wheels each carrying 17 t. (16.7 Engl. tons). The total weight is therefore 82 t. (80.7 Engl. tons). The engine consists of three double-acting two-stroke cylinders of 380×600 mm. ($14\ 15/16$ in. $\times\ 23\ 5/8$ in.).

The available drawbar horse power is 600. The driving wheels are 1.75 m. (5 ft. 8 29/32 in.) diameter; the vehicle speed attained at an engine speed of 335 r. p. m. is 110 km. (68.3 miles) an hour.

The three driving cylinders M (fig. 7) are arranged side by side; the outside cylinders drive the trailing pair of coupled wheels A, and the middle cylinder the leading coupled axle B, a crank axle.

Two Roots blowers C, carried on the trailing bogie D, supply the scavenging air. The whole of the control gear is grouped at E in the driver's cab, and include the fuel injection pumps for starting as well as the air inlet valve to the cylinders. A shaft F, driven by the second coupled axle, controls the starting fuel injection pumps.

An auxiliary three-cylinder 240×430 mm. ($9\ 7/16$ in. $\times\ 16\ 15/16$ in.) four-stroke engine P, drives the three-stage air compressor N which supplies the scavenging and pressure-charging air. This auxiliary engine also drives the fans V and W (the latter by electrical transmission gear), the water pumps, and a dynamo G.

The radiator R of the auxiliary engine is fitted near the latter, while the radiator S of the locomotive engine cylinders is fitted at the other end. The reserve supply of compressed air is held in a battery of bottles U of 2 m³ (706 cu. feet) capacity.

The locomotive which was completed in 1933 can start a train of several hundred tons. The change over from pressure-charged working to ordinary running, takes place without shock.

A good deal of work had to be done to get entirely satisfactory combustion

Fig. 8. — Deutz diesel locomotive with direct drive.

during normal running, but the locomotive now fully meets the specification drawn up.

The separate compression method.

When separate compression is used, the main engine, as we showed at the beginning of this article, does not have to draw its air supply from outside : each cylinder receives, from a motor compressor group, the full charge of air under high pressure at the beginning of the exhaust stroke. The engine works as a two-stroke engine without admission or compression stage, so that the full return stroke is used for the exhaust. As a self-contained group supplies the air to the engine, the extent to which the cylinders are filled can be independent of the speed of rotation. The engine can therefore be coupled direct to the locomotive driving wheels and the degree of admission can be varied as though we were dealing with a steam engine.

A primary advantage of this method is that the indicated power of each of the three essential elements of the arrangement — main engine, compressor and auxiliary engine driving the compressor — is less than the maximum indicated power of the locomotive, unlike locomotives with indirect drive : for example, with electric drive the diesel engine, the generator it drives, and the motors driving the axles have each to be capable of developing and absorbing the maximum power of the locomotive.

If we admit that the power absorbed in compression represents theoretically 35 % of the power developed, the engine, in the case of separate compression, has only to supply 65 % of the power it would have to develop if it did its own compressing.

Ignoring losses, to get the same useful power as with an ordinary 100-H.P. engine, a main engine (of the two-stroke type defined above without compression) with the same volume as an ordinary two-stroke engine of 65 H.P. with a 35 H.P. compressor and an auxiliary engine of 35 H.P. is needed. Of course, if mechanical losses are taken into account, these figures have to be increased appreciably.

With the separate compression engine, the thermal efficiency can be increased above that possible with an ordinary engine in which the degree of expansion is always equal to that of the compression, safe in the exceptional case when a particular system of rods is used to make the expansion stroke longer than the admission, as in the Andreau engine described in the *Génie Civil* (see number of 7th February 1925, page 144). The return stroke in an engine with separate compression can be increased to get a much greater expansion and so reduce the loss during exhaust, although the air is introduced into the cylinder under a pressure corresponding to the normal compression value.

In the *Zeitschrift des Vereines Deutscher Ingenieure* of the 7th April, Messrs. Grantz and Rieppel reported the results of comparative tests they had made between the pressure-charging method and the separate compression method.
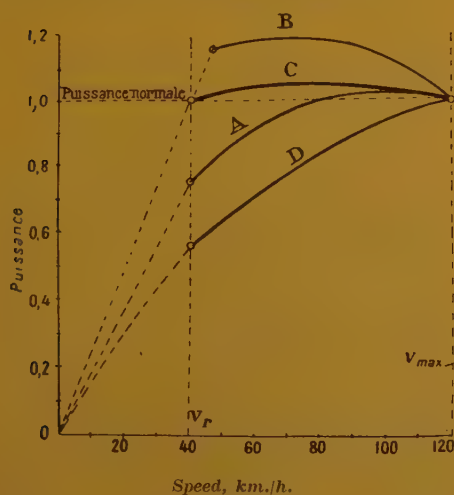
Fig. 9. — Curves of the maximum available power of a direct drive locomotive, for each speed.

A, Steam locomotive.
B, Diesel locomotive with pressure charging.
C, Diesel locomotive with separate compression.
D, Deutz-diesel locomotive.

Note : Puissance normale = normal power.

Figure 9 gives the comparative power and speed curves of the locomotive for the four systems : steam locomotion, diesel-engined locomotive (with pressure charging, with separate compression, or on the Deutz system).

The diagram is drawn on the assumption that the four types of locomotive develop the same power at the maximum speed V max. and that the speed V_r, within which the limit of adhesion may be reached, is equal to two thirds of the maximum speed.

Another interesting comparison is that of the total weight of the engine. As the weights are in proportion to the indicated horse power, it will be sufficient to compare the sums of the indicated horse powers of the different piston engines.

Let us take a locomotive of 100 effective H.P. at the wheel tread. Taking the efficiency of the direct drive as 95 %, the mechanical efficiency of the separate compression engine as 82 %, and that of the engine with pressure charging at 78 %, the indicated horse-power is 128 for the first, and 135 for the second.

The power per litre of cylinder volume of the engine with separate compression is greater than that of a similar two-stroke engine, because it has no compression stroke and also because the rate of expansion is greater than usual. The power developed per litre of cylinder volume is estimated at about 1.67 times that of an ordinary engine, so that the separate compression engine of 128 H.P. presents itself as an ordinary engine of 128/1.67 or 76.5 H.P. only.

The volume of air to be compressed per hour being 10.75 kgr.-molecule for the separate compression engine, and 19 kgr.-molecule (12.55 of which to be compressed outside for charging pressure) for the other engine, the indicated horse-power of the compressor reaches 52.2 for the first engine, and 65.6 for the second (the work of compressing

one kgr.-molecule in its compressor is equivalent to 3 300 kgr.-calories = 13 095 B.T.U.).

Taking the mechanical efficiency of the compressor at 80 % and that of the diesel engine driving it at 82 %, the latter engine must develop an effective H.P. of 85.6 in the case of the separate compression engine, and 100 H.P. in the case of the engine with pressure charging. To get 100 effective horse power at the wheel tread, the total installed horse power in the locomotive (main engine, compressor and compression engine) must be 76.5 + 56.2 + 85.6

= 218.3 in the case of direct drive with separate compression engine, and 135 + 65.5 + 100 = 300.5 in the case of direct drive with an engine with pressure charging. The total installed horse power in the Deutz locomotive is some 190 for an effective horse power of 100.

Messrs. Grantz and Rieppel complete their short article by the diagram of figure 10, comparing the installed horse power for the two direct drives we have just analysed, and for the two indirect drives — ordinary compressed air, and electric. The authors also give
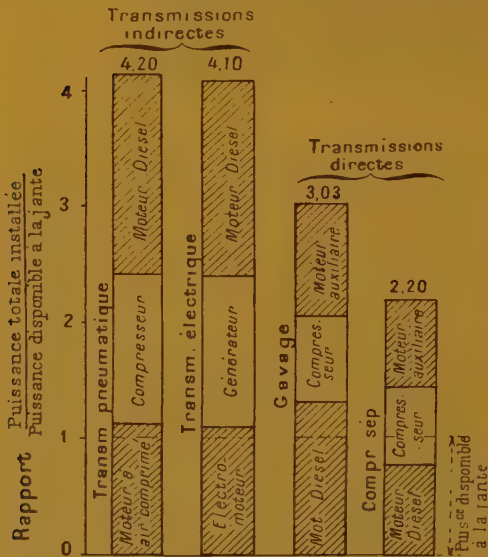
Fig. 10. — Comparison between the total installed power for the different types of diesel locomotives with indirect or direct drive.

Explanation of French terms:

Rapport = ratio. — Puissance totale installée = total installed power. — Puissance disponible à la jante = power available at the wheel tread. — Transmission pneumatique = pneumatic drive. — Moteur à air comprimé = compressed air engine. — Compresseur = compressor. — Moteur Diesel = dicsel engine. — Transmission électrique = electric transmission. — Electro-moteur = electric motor. — Cavage = pressure charging. — Moteur auxiliaire = auxiliary engine. — Transmissions indirectes = indirect drives. — Transmissions directes = direct drives.
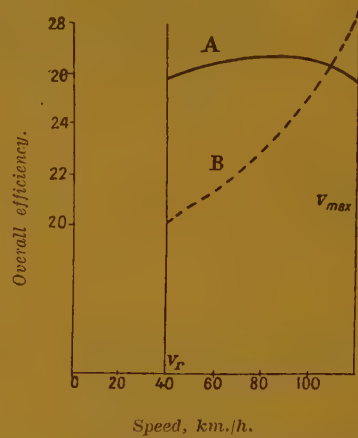

Fig. 11. — Variations in overall efficiency of direct-drive diesel locomotive with separate compression (curve A) or with pressure charging (curve B).

(figure 11) — though without the calculation on which they are based — the relative overal efficiency curves for the locomotive, in terms of the speed for the two above mentioned direct drives.

The Deutz system with pressure charging requires about 14 % less installed horse power than the system with separate compression. Against this, the thermal efficiency may be lower, at least when starting, and the power curve of the diesel locomotive with direct transmission may not follow that of the steam locomotive so closely.

New marshalling yard near Basle, Swiss Federal Railways.

(The Railway Gazette.)

Nearly four years ago the Swiss Federal Railways opened a large marshalling yard at Muttenz, just outside Basle, which was designed to facilitate the goods working at that place and to enable certain movements to be concentrated there, which were formerly carried out at other stations. Before the formation of the Swiss Federal Railways as a unified undertaking, the various company-owned lines possessed yards of their own, but the work was often carried on in them with little regard to the convenience of adjoining systems. Some of the yards, too, were not large enough to cope with the traffic and considerable delay was frequently experienced. This method of working was naturally very uneconomical and the Federal Railways management determined, before the war, to improve the situation by constructing a new yard at the most convenient spot. This was considered to be Basle, the principal gateway to Switzerland, where a number of important main routes from other countries converge, such as those of the Alsace-Lorraine and Baden lines, and thence lead on to Olten, Berne, Lucerne, Lausanne and beyond.

Stations at Basle.

The principal passenger station at Basle is that of the Swiss Federal Railways. The German Reichsbahn also has a station in Swiss territory, with a connecting line to that of the Swiss Federal Railways. The Swiss station was opened in 1906. There is also the Wolf marshalling yard, which dates from 1874 and has been several times enlarged, and the St. Johann and Kleinhüningen goods stations, connecting with quays on the Rhine. As traffic was freed from other yards it increased at Basle and the provision of better facilities became imperative. The Wolf station could not be extended, and it was therefore decided to build an entirely new one between the Birs River and Pratteln, alongside Muttenz station. The traffic here is mainly through west to east and east to west, but there is a certain amount of it which arrives from, say, the west and has to be sent away again in the same direction. After due consideration of all the requirements it was decided to arrange the new yard as a double one, the southern half serving the traffic from Germany into Switzerland and the northern half that proceeding the reverse way. This made the layout rather extensive, but it was well suited to deal with the work and, as there is a great deal of transit traffic from foreign systems necessitating customs and other formalities, it was considered preferable to err, if at all, on the side of providing more facilities than were absolutely essential under normal conditions. This arrangement of the two yards allows for right hand running of trains, although in Switzerland the reverse practice is followed. At the time it was chosen there was considerable discussion as to whether a change in this respect ought not to be made, and the working on the Alsace-Lorraine and Baden lines was, of course, already right handed. The war led to the Alsace-Lorraine line becoming French, with some chance of a reversal, and all idea of changing in Switzerland was finally abandoned. It was agreed, however, not to alter the plans of the yard on that account.

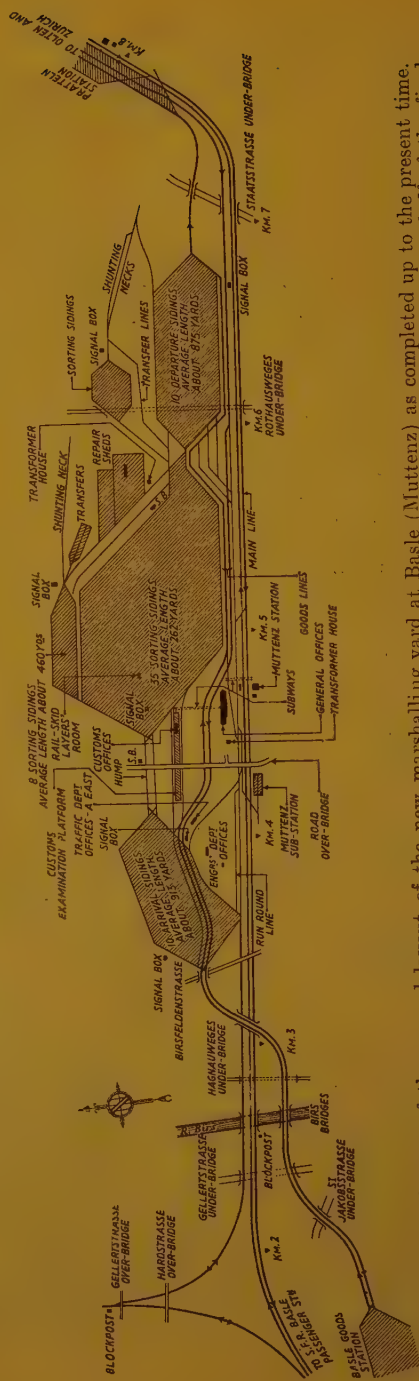Fig. 1. — No. 4 cabin, showing rail brakes and sorting sidings.

Fig. 2. — Diagram of the general layout of the new marshalling yard at Basle (Muttenz) as completed up to the present time. This deals entirely with west to east traffic from Germany into Switzerland, and will form the southern half of the final yard when it is completed, the northern half then dealing with east to west traffic.

Construction started.

The work was begun partly with the intention of providing alleviation in the unemployment situation in 1922, but only the southern half of the yard, serving west to east traffic, has been built as yet. The traffic in the opposite direction is still dealt with at the Wolf yard. The south yard is constructed on the hump principle, as will be eventually the north yard, with two humps of different heights for summer and winter service. The reception section of the yard is more extensive than is usually the case, a certain reservoir for wagons being essential at a frontier station. The wagons pass as usual from this portion of the yard to the marshalling sidings via the hump, and the track layout is such that trains can leave them directly in the direction of Pratteln. The upper group of lines in the sidings is for vehicles which are not going through to the east. There are also special customs examination lines and lines for wagons of which the ultimate destination has not been settled by the time they arrive.

Connections with running lines.

The connections with the running lines had to be planned with great care to minimise interference with ordinary train movement, and with this object in view, a number of fly-over junctions were constructed and certain lines rearranged to give more convenient connections. An entirely new line has been built to connect the Wolf yard with the new Muttenz yard, passing over the main passenger lines and the connecting line to the Baden station. The construction of this line necessitated the building of a number of important bridges over the Birs River and various roadways. This additional facility was brought into use in November, 1932, in the early part of which year some extensions at the eastern end of the yard were opened for traffic.

Equipment of the yard.

The signalling and point working is on the all-electric system, and there are several cabins already at work. The principal pairs of points leading from the hump lines to the group of sorting sidings are fitted with A.E.G. rapid acting point machines controlled from a desk pattern frame in the hump cabin. Frölich hydraulic rail-brakes are also operated from this cabin. In case of

Fig. 3. — Interior of hump cabin, showing special control frame. On left pneumatic dispatch apparatus.

emergency, certain points can be worked from a special reserve cabin situated at the hump itself. The hump cabin apparatus is of the magazine storage system, in which the necessary controls are stored up in advance before shunting begins. Track circuits at the points, worked by the descending wagons, go-

vern the release of the controls in turn. Pneumatic tube apparatus is provided between the hump, the cabin and the yardmen to enable marshalling sheets and other instructions to be exchanged as rapidly as possible. Electric motors of the Siemens and Halske type are used for points which are not required to be rapid acting, and similar apparatus controls the semaphore signals. Signals leading to and from the main line are controlled by the lock-and-block system generally used in Switzerland. The movements over the hump are directed by means of a three-colour light signal, supplemented by electric hooters for use in foggy weather.

The cost of the complete scheme as estimated according to the plans prepared in 1918, was 37 million Swiss francs, but this figure will probably have to be increased by 13 millions on account of the rise in prices and certain improvements and extensions not at first included.

MISCELLANEOUS INFORMATION.

[621 . 392 (.73) & 625 . 232 (.73)]

Welded coach construction on the Chicago, Milwaukee, St. Paul and Pacific Railroad.

(Engineering.)

Fig. 1. — Welded body on underframe.

An interesting example of the application of welding adopted with the object of reducing weight, is given by the annexed illustrations of railway stock under construction in the shops of the Chicago, Milwaukee, St. Paul and Pacific Railroad. The coaches, 50 of which are being built, are intended for the Chicago-Pacific Coast service, and it is stated that the adoption of welding has made possible a saving of 35 % in weight, which should bring down operating costs, as well as resulting in a considerable saving in first cost for material.

The coaches are 80 ft. 8 in. long, 10 ft. wide, and the roof is 13 ft. above rail level. The total weight of the new design is 96 000 lb.,

compared with 146 000 lb. for the type previously in service. Figure 1 shows the completely-welded body on its underframe. All projections on the exterior have been avoided, and, where possible, all edges have been rounded to reduce air resistance. Welding has been employed for the whole of the body, while the centre longitudinals, bolsters, buffer beams and body end-sills are built up of structural shapes and plates, joined by arc welding. The floor and body are composed of pressed plating, with right-angle flanges on the various contiguous panels or « pans ». The floor pieces are assembled upside down, and the flanges spot welded at intervals, after which the whole assembly is turned over and

Fig. 2. — Welding up side panels.

the Vee-joints continuously welded by the shielded arc process, to produce a flush finish. The floors are built of pressed steel sheets, 1/8 inch thick, each pressing extending right across the floor to the side sills. The floor so built up is connected to the framing longitudinals by intermittent welding.

The bodywork consists of pressings welded together, the side sills being of 4-inch by 8.2 lb. Z-bars, extending from one corner post to the other. The sides, one of which is shown being welded in figure 2, are built of three standard pressings, one extending to the full height between the windows, one below

Fig. 3. — Automatic welding machine at work on roof.

the windows, and one above. The sheeting used is again 1/8 inch thick, the flanges being formed to give both angle and channel effect, to add to the stiffness. The flanges are again spot welded and the Vees filled in with weld metal to give a flush finish. The pressings used in the sides are punched for bolting the flanges together; later, these holes are filled. In this instance, the Vees are first filled, the side turned over and the flanges spot welded. The window frames are formed of No. 12 gauge steel with flanges projecting inwards.

Figure 3 shows a roof under construction. In this instance, centre panels of 1/16-inch plate are employed, pressed with deep flanges on all four sides, the side plates being, however, of 3/16-inch plating. Flat strip, 1/8 inch by 3 inches, is inserted between the centre flanges to form a ridge pole. The strip is inserted to project above the surface, and is melted down when welding in the Vees. Figure 3 shows the automatic machine at work on a roof.

An excellent finish is obtained due to the regular bead deposited by the automatic method, warping being reduced to a minimum by a water-cooling system of drilled pipes in connection with the welding jig. The pipes keep a continual spray playing on the under-side of the joint being welded, and heat is carried off so efficiently that the bare hand can be placed on the plating within 5 inches of the arc. By localising the heat in this way, very little warping is experienced. No grinding is necessary after automatic welding. The welding has been carried out by the « Electronic Tornado » and hand welders of the Lincoln Electric Company, Cleveland, Ohio, U.S.A., who also supplied the electrodes. We are indebted to the same company for the photographs reproduced herewith.

NEW BOOKS AND PUBLICATIONS.

[621. 392]

Handbook for electric welders. — Edited by J. H. PATERSON, D. Sc., F. I. C. — One volume (8 3/4 × 5 1/2 inches) of 151 pages with tables and many illustrations. — 1934, London, Murex Welding Processes Ltd., Ferry Lane Works, Forest Road, E. 17. (Price : 2 sh. 6 d. net.)

The manual on arc welding edited by Dr. Paterson for the « Murex Welding Processes Ltd. » Company, four editions of which have been issued within two years, here appears in an entirely new form : the well-known elementary facts have been ommitted, and the eight succeeding chapters, each of which has been written by a specialist, deal with questions of present-day interest in electric welding. It now rather forms a manual for improvement in the art of arc welding.

The first two chapters deal with the characteristics and conditions of working of the different types of electric welding equipment, both direct and alternating current, the theory of the electric arc, and the properties of the different qualities of electrodes at present in use.

The work then goes on to lay down the principles of welding mild steel, horizontally, vertically, and overhead. Chapter IV deals with the present state of the application of the electric process : a) to cast iron, by developing in particular the process by studs; b) to rustless steel; c) to copper and bronze.

Special chapters deal with the application of metallography to the examination of the welds; with the study of the physical properties of welds; with the mechanical testing of welded parts by tensile, fatigue and bend tests; with the strength of welded joints; with the systematic control of welding operations. Each chapter includes a bibliography of the matter dealt with, and an appendix contains the official English specifications and those of Lloyds Register on the use of the electric arc, as well as metric tables.

[625. 248 (43) & 656. 213 (.43)]

Dr.-Ing. Kurt WALTER, Regierungsbauführer. — **Die Technik und Wirtschaft der Hygiene im Tierversand bei der Deutschen Reichsbahn** (*The technique and economics of hygiene in transporting animals on the German State Railways*). — One vol. (8 1/2 × 6 1/4 inches), of X + 218 pages, with 51 tables and 35 figures. — 1934, Berlin, Verkehrswissenschaftliche Lehrmittelgesellschaft m. b. H. bei der Deutschen Reichsbahn, Voss-Strasse, 6. (Price : 7.50 Reichsmark.)

This book is an original scientific study of the equipment for disinfecting cattle trucks on the Reichsbahn. Such equipment is examined from the technical and economic points of view, so that the work can be used to form a judgment on the existing equipment and as a basis for new constructions. The first part of the book deals with the hygiene of animal transport and the methods of disinfection.

In the second part, the author develops the technique of cleansing and disinfection. He gives the arrangements to be adopted and the regulations to be followed in order to proportion the equipment to the work to be done. He also examines the organisation of the work in order to fix the time needed for the various operations. This report is based upon statistics relating to 40 disinfecting stations on the Reichsbahn.

The third part develops the main thesis of the book : the economics of such equipment. The author shows how the cost can be reduced by a rational arrangement of the buildings and machines. By means of a study of the equipment and the organisation of the work, he has established a basis for calculating the cost, and he shows how the results of the working of such equipment can be costed by methods which not only give the cost of treating the various classes of wagons, but also make it possible for the staff to show almost automatically the influence of the working method.

E. M.

[656. (02)]

Dr.-Ing. Prof. PIRATH (Carl). — **Verkehrseinheit und Verkehrspolitik** (*Unity in Transport and Transport Policy*). — Note presented to the 4th Annual Study Conference of the German State Railway Company. — One pamphlet (8 1/4 × 6 inches) of 34 pages. 1934, Berlin, W 9, Verlag der Verkehrswissenschaftlichen Lehrmittelgesellschaft m. b. H. bei der Deutschen Reichsbahn, Potsdamer Platz, 1. (Price : 1.65 Reichsmark.)

During the last ten years, transport methods and organisation have undergone great changes. The development of new equipment, and its operation on principles differing much from railway practice, can have far reaching consequences.

The note presented by the author is an important contribution to this question of a transport policy, which has arisen in most countries.

He defines the economic mission of the whole of the transport system of a country, the benefits of which must meet the legitimate requirements of the various districts and different classes of customers. He goes on to discuss the causes and consequences of the failure to maintain unity of action in transport matters and examines the present situation from the technical and operating points of view in turn, and then the general organisation, and finally deals with their effects from the general and economic points of view.

After having shown how the dangers of a transport monopoly can be avoided, he endeavours to define the principles upon which a transport policy should be based.

This lecture, given in 1933 and now published in pamphlet form, has not lost any of its interest. The author has added a new chapter in which he shows the objects aimed at by the authorities in his own country in regard to the transport problem, and the steps already taken to carry them out.

[621. 132.8 & 621. 43)]

Modern Traction for Industrial and Agricultural Railways. — One volume (11 1/2 × 8 3/4 inches) of 182 pages, profusely illustrated. — 1934, London E. C. 4, The Locomotive Publishing Company Ltd., 3, Amen Corner. (Price : 15 sh. net.)

Transport organisation for large quantities of materials or products, in connection with mines and quarries, or forestry and farming on a large scale, is often a difficult problem, especially since the introduction of modern high production methods. The Locomotive Publishing Company has just issued a very complete study, with many illustrations, on the different methods of traction used in such cases. It is divided into four main parts, dealing respectively with steam locomotives, compressed-air locomotives, petrol or internal-combustion-engined locomotives, and electric locomotives.

Each chapter includes the principles upon which each kind of locomotive functions; a description of the standard designs, as well as the types adapted to special conditions. For example, in the case of steam locomotives, there are special chapters dealing with types of locomotives with flexible coupled pairs of wheels, gear-driven locomotives, articulated locomotives (Mallet, Beyer-Garratt, Kitson-Meyer, Sentinel, etc...), locomotives without fireboxes, i. e. with steam containers fed by stationary generators.

The important chapter on locomotives with internal combustion engines gives, among other information, a description of the many types of diesel locomotives now used, with mechanical or electrical transmission; the part dealing with electric locomotives includes, on the one hand, locomotives with accumulators, and on the other, locomotives picking up current from a trolley-wire. Very

complete information is given about the types of electric traction motors and the kinds of accumulators used, also a description of special kinds of locomotives, in particular those used in connection with coke ovens, electric tractors for towing boats, tractors with entirely automatic control used on the London Post Office Tube Railway.

The last chapters are devoted to locomotive cranes, to an examination of the fundamental principles of mechanical traction, and the characteristics of the fuels used. Finally a very fully documented chapter deals with axle boxes of the Isothermos type, and the various designs of roller-bearing boxes.

This brief survey will make it possible to appreciate the abundance of information collected in this interesting book; it will undoubtedly be welcomed by the managers and engineers of large industrial, forestry and agricultural undertakings.

A. C.

[621. 8]

LEGRAS (Marcel), Consulting Engineer. — **La manutention mécanique** (*Mechanical handling*). — One volume (6 3/4 × 4 3/8 inches), of 220 pages, with 92 figures. — 1934, Paris, Librairie Armand Colin, 103, Boulevard Saint-Michel. (Price unbound : 10.50 French francs.)

This work forms part of the Armand Colin Library, Civil Engineering Section. It is conceived on a new and original plan. As the author remarks in his preface, it has not been written for the builders but for the operators who have to install and work many kinds of handling equipment about which they must know the characteristics and limitations so as to be able to solve in a satisfactory manner the problems that arise. From this point of view, this little work will be of great interest to railway engineers : Modernisation of the railway equipment calls for the ever increasing use of mechanical handling devices.

The work is divided up into three chapters : the first examines the nature of handling problems, and analyses their

main factors, in particular : the nature of the materials to be handled, the local conditions, and the special circumstances to be taken into consideration to adapt the equipment.

There follows an important chapter on handling equipment, its classification, a description of the various elements, and the conditions under which they are used, their advantages and drawbacks, their output, the power required, etc...

The third chapter deals with the solution of several typical problems, most of which are more directly concerned with railways, such as : unloading wagons, dumping the materials, picking up the materials, loading wagons.

Finally, there is an appendix dealing

with various supplementary questions : the driving of handling equipment, safety devices, control apparatus, etc...

This brief survey of the plan of the work shows that the engineer will find in this clear, methodical, and well thought-out study of the principles of mechanical handling, a safe and valuable guide to solve the problems arising when considering industrial and railway equipment.

A. C.

[656. 1 (.43)]

Dr.-Jur. Klaus LENGEMANN. — **Reichsautobahnen in Staat, Wirtschaft und Recht** (*The State Motor Roads Company considered from the point of view of its relations with the State, and from the economic and legal standpoints*). — One pamphlet (8 1/4 × 6 inches) of 74 pages. — 1934, Berlin; published by the Verkehrswissenschaftliche Lehrmittelgesellschaft m. b. H. bei der Deutschen Reichsbahn, Potsdamer Platz, 1. (Price : 3.30 Reichsmark.)

Reichsautobahnen (State Motor Roads) is the name of an undertaking set up according to the law of the 27th June, 1933, to build and operate roads for the exclusive use of motor traffic operating as public services.

The proposed roads are to form a special system quite apart from the ordinary roads, which are open, in principle, to all traffic, and this road system, which is recognised and classified as a public service, will be operated by a Company set up by the Reichsbahn (German State Railway Company). In fact, it is to the latter that the power to set up an affiliated undertaking with the object mentioned above has been confided. Because of this, the management of the railway system and that of an important road system will be in the same hands.

It is hoped that this new organisation will have a happy influence on the general economics of the country by making it possible to get better co-ordination of the methods of transport. It will doubtless strengthen the position of the State in view of the development of motor traffic.

The author, after explaining the circumstances under which the Company was set up, analyses its relations with the State and shows the various aspects of the evolution which has occurred in the matter of public law. He defines the legal position of the Company, explains the regulations governing the composition of the Board of Directors, the management, the councils, and how the working is to be organised. He shows how the State has secured for itself control over the Company and defines the general policy of the *Reichsautobahnen* and the methods to be used to built up the system... Nearly all the roads have to be built (according to a plan approved by the higher authorities represented by the Inspector General of German roads); the Company can, however, include existing roads in its system. The construction will be greatly facilitated by the new regulations passed in order to speed up expropriation formalities.

A whole paragraph is devoted to the legal aspect of the charges which the Company is authorised to impose for the right of using its roads.

In his final remarks, the author insists upon the value of considering the undertaking as a self-contained administration responsible for carrying out a definite task in the economic field.

The appendices give the official text of the law and subsequent administrative decrees.

ACKNOWLEDGMENT.

Bulletin of the Railway Congress, August 1934 issue, page 822.

Article headed :

Re-making and blanketting clay formations under main lines in service,

by Mr. GIRAL, Divisional Chief Engineer,
Alsace-Lorraine Railways.

We wish to draw attention to the fact that this article, which we reproduced from *The Railway Engineer,* was originally published in the *Revue Générale des Chemins de fer.* Owing to a printer's error, a footnote acknowledging this fact, which appeared in *The Railway Engineer,* was, to our regret, inadvertently dropped.